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ESTIMATES ON A NEW WATER SUPPLY for San Francisco, Cal., made by C. E. Grunsky, M. Am. Soc. C. E., City Engineer, range from $16,200,000 for a single 48-in. pipe line of 30,000,000 gallons capacity from the Stanislaus and Tuolumne rivers, to $34,178,000 for a double 56.11-in. pipe line with a combined daily capacity of 60,000,000 gallons, drawing water from the North Yuba River. The various projects include about 100 days' storage near the city. The estimates for the various schemes, seven in all, show an investment per 1,000,000 gallons of daily supply of from $726,000 to $487,000. The cost, likewise, per 1,000,000 gallons actually delivered, up to the capacities of the several pipe lines, including interest at 3½%, sinking funds for 40-year and shorter periods, according to the life of the several parts of the works, ranges from $69.57 to $106. The report is a preliminary one. The city is now supplied by a private company.

THE WATER METER SYSTEM AT NORFOLK, VA., for which Mr. W. T. Brooke recently recommended an expenditure of $109,000, has been voted down, 10 to 2, by the city council. The alternative appears to be nearly double that sum for new mains, to say nothing of the expense of purifying and pumping water for people to waste.

NOMINAL DAMAGES FOR UNDERGROUND WATER alleged to have been diverted from farm land by the Brooklyn water-works have been awarded to Frederick Reisert by Judge Josiah T. Marean. The plaintiff sought $75,000 damages.

SEWAGE DISPOSAL PLANS FOR COLUMBUS, O., have been approved by the State Board of Health and a special election is proposed for their ratification by popular vote. Septic tanks and filter beds are proposed. The estimated cost of all the necessary work, which apparently includes intercepting sewers, is $2,250,000. The approval of the State Board of Health is subject to the following conditions and recommendation:

(1) That the sewage disposal plant shall be fully completed at the earliest time practicable.
(2) That the area of filter beds shall be amply sufficient to purify all the sewage.
(3) That in the operation of the plant after its completion, raw or partially purified sewage shall at no time be discharged into the river in amounts sufficient to create a nuisance.

The board recommended, without making it a condition of approval, however, that only a sufficient number of septic tanks be constructed in the beginning to determine by further study the number and size of tanks that will ultimately be required.

THE SEWERAGE ASSESSMENT PLAN in use at Brockton, Mass. (Engineering News, July 19, 1894), has been upheld by the U. S. Supreme Court, which affirmed a decision of the Superior Court of Massachusetts. Under the original plan the total cost of the sewerage system, including the receiving reservoir, pumping plant, force main and filter beds is divided between the city at large, which pays one-fourth, abutting property, which pays a second fourth on a combined area and frontage basis, and the users of the sewers, who pay one-half the cost, in the form of quarterly rentals. How fully these proportions have been adhered to we cannot say. Mr. Chas. R. Felton, City Engineer, informs us that the system of "assessments combines with the frontage and area plan a rental payable quarterly, the same as for water." We presume the city's share is left, in a measure, to adjust itself, the city carrying some of the capital charges pending the extension of the sewers and the making of connections therewith.

AN INJUNCTION AGAINST DISCHARGING sewage into Onondaga Creek, at Syracuse, N. Y., has just been granted on petition of property owners. The city of Syracuse was the defendant.

NEW BIDS FOR GARBAGE DISPOSAL IN NEW YORK will be requested, this time for one instead of five years. This is due to the unanimous disapproval, by the Board of Estimate and Apportionment, of the bid of the New York Sanitary Utilization Co., which called for $232,000 a year, against the $90,000 a year which it has been receiving for the last five years.

ASPHALT PAVING ON BROADWAY, NEW YORK, between Canal and Fourteenth St., is to cost the city $5.49 per sq. yd., including a ten-year guarantee. Only two bids for the work were received on July 9. The Barber Asphalt Co. bid the price named and the Warren-Quinlan Co. bid $6.26. The price is said to be due, in part, to the heavy foundation required and the wear and tear due to the heavy traffic on so important a thoroughfare.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred near Marshall, Mo., on the Chicago & Alton Ry. on July 10. A section of the Chicago and Kansas City express collided head-on with a stock train, resulting in the deaths of 22 people and the serious injury of many others. The accident is said to have been due to a misunderstanding of orders.——A bridge near Springfield, Pa., on the New York, Chicago & St. Louis Ry. collapsed under a freight train on July 11, resulting in the deaths of nine men and the serious injury of a number of others. The structure was considered unsafe and the ravine was being filled. At the time of the accident a freight train had backed onto the bridge and three cars loaded with broken stone were standing on the span when the latter suddenly gave way, precipitating the cars and bridge upon a party of workmen 80 ft. below.

A MAGNETIC RAIL BRAKE for street cars has been placed on the market by the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa. It consists of a horseshoe magnet suspended over each rail between the wheels. When the car controller is placed at the brake notch the motors become generators, supplying current to the brake magnets. The magnetic pull draws the poles of the latter down upon the rails. The magnet is so hung that ordinary brakes are at the same time forced against the car wheels. When the current is cut off the brake is lifted by springs. The excess of energy delivered by the motors is expended in heating resistance coils, which in the winter time may be the electric car heaters.

WELDING CRACKED LOCOMOTIVE FRAMES in place is a feat which is being performed at the West Oakland shops of the Southern Pacific Ry. A small furnace of fire brick is built around the frame at the crack and an oil burner is then introduced and operated till the frame is brought to a welding heat. At the June meeting of the Pacific Coast Ry. Club, Mr. Kellogg, the foreman of these shops, stated that an engine was recently brought in off the road at 8.30 a. m. with the main frame broken under the rocker box. In 22 hours the engine was back on the road hauling its train.

A FIRE INSURANCE POLICY does not protect the insured against damages caused by an explosion, unless fire ensues and in that event only for the damages done by fire. A test case recently tried in New York grew out of the explosion in the Tarrant building on Oct. 29, 1900. The plaintiff owned a store which was wrecked by the explosion in the Tarrant building, 180 ft. distant, but was not injured by fire. The court in giving a verdict for the insurance company showed that the company's liability was definitely limited in the policy in the terms quoted above.

FACTORY AND MILL FIRE APPARATUS is treated in Circular No. 78, issued by the Boston Manufacturers' Mutual Fire Insurance Co.; the last similar circular having been sent out in 1892. This circular submits lists of the makers of apparatus recommended, including pumps, hydrants and valves, meters and by-pass, portable fire extinguishers, play-pipes, housing for hose and appliances, reservoirs and tanks, buckets, stand-pipe and hydrants, sprinklers, etc. The circular concludes with the organization of mill fire departments, inspection forms and notes on the discharge of pipes, etc.

THE NEW YORK AND BOSTON CANAL ROUTE is being investigated by the Massachusetts Harbor and Land Commission, in obedience to a late resolution of the Massachusetts legislature, appropriating $10,000 for the survey. The project calls for a survey and estimate of cost of a ship canal between Taunton River and Boston Harbor, the work to be done under Mr. Henry B. Wood, M. Am. Soc. C. E., late Chief Engineer of the Massachusetts Topographical Survey. The direct distance between the points named is about 30 miles, and such a canal would admit vessels directly from Narragansett Bay to Boston Harbor. Report must be made to the legislature by Jan. 15, 1902.

THE SANTOS-DUMONT AIRSHIP made a very successful trial trip in Paris on July 12. The machine used was a cigar-shaped balloon, 111½ ft. long by 20 ft. diameter, propelled by a petroleum motor of 16 HP. The propelling screw was about 13 ft. in diameter and made 200 revolutions per minute. The machine is supported by a triangular framework of aluminum and white pine, 50 ft. long. The motor is suspended at a point 23 ft. from one end of this framework, and at the same distance from the other end is suspended the car for the operator. This balloon was steered from St. Cloud to the Longchamps race course; this course was circled six times at an average speed of 25 miles per hour, and the machine was made to descend to the ground and rise again. The operator then started for the Eiffel tower, and owing to some slight accident he descended easily in the Trocadero Gardens and repaired damages. He then rose again, made a complete circuit of the tower and returned to Longchamps. Including stoppages, the voyage lasted 66 minutes. Mr. Santos-Dumont uses no ballast and yet easily maintained his altitude of from 100 to 270 m. He will now compete for the Henri Deutsch prize of 100,000 francs, for the quickest trip around the Eiffel tower. While the French press loudly proclaims that navigation in the upper air is now an accomplished fact, it should not be forgotten that on Aug. 9, 1884, two French officers—Krebs and Renard—did practically the same thing. They started from Meudon, near Paris, with a dirigible balloon, and after traveling nearly 5 miles at a rate of 12 miles an hour, they descended almost exactly at the point of departure. On Nov. 8, 1884, they traveled twice over the same course. It was supposed then that the problem was solved—but it was not.

ELECTRICITY DIRECT FROM COAL is the subject of a patent issued to Hugo Jone, of Chicago, Ill., on June 25. The battery is described by the "Electrical World and Engineer" as follows:

There is a retort surrounded by a cylindrical case containing a battery of four cells. The furnace gases from the retort circulate around the furnace and against the inner side of the said case containing the cells, thereby heating the latter. Each cell is divided into three sections by partitions of porous clay. One of these sections contains nitric acid, the adjacent section contains sulphuric acid and the third and larger section contains a ferric chloride solution. In the latter section there is a lead electrode, and the nitric acid section contains a carbon electrode. The operations are as follows: A suitable quantity of sulphate of lead is placed in the retort with a quantity of coal nearly sufficient to reduce the sulphate to sulphide, and the mixture is then heated until all of the coal is oxidized. The sulphide is freed from impurities which may have been brought into it by the coal, and is then mixed with sulphate of lead in sufficient quantity to yield metallic lead and sulphur dioxide, which reduction is effected by again applying fuel heat to the retort. The sulphur dioxide passes through a pipe into the larger section of the several cells, reducing the ferric chloride therein to ferrous chloride. Previous to this the generation of an electric current is started by putting the lead electrodes into the larger section and suitably connecting them with the carbon electrodes. The current may be considered as consisting of two currents, one generated by the action of the ferric chloride of the lead electrode, and the other by the action of the nitric acid through the interposed porous walls and sulphuric acid by means of molecular exchange of ferrous chloride. The flow of sulphur dioxide is so regulated that the sulphuric acid formed is not more than sufficient to decompose the chloride of lead formed in the battery reaction. The lead in the retort is allowed to flow into a pan where it is suitably shaped or solidified for an electrode. The sulphate of lead deposited by the battery is allowed to accumulate, and at intervals is drawn off by means of siphons, and the deposit of sulphate of lead on the lead electrode removed. The temperature of the battery is regulated so that the nitric acid which enters into the sulphuric acid section is evaporated, the vapors being passed through a condenser coil and there condensed again to nitric acid, flowing back into the nitric acid sections through a pipe. This process of distillation, oxidation and condensation is kept up by regulating the temperature of the battery and supplying sufficient cooling water to the condenser. Thus oxygen is supplied to the nitric acid, while the generation of electric energy with consumption of oxygen goes on. The e. m. f. of the cell at 100° C. is said to be about 1.75 volts.

A VISITING COMMITTEE to the National Standardizing Bureau has been appointed by the Secretary of the Treasury, in accordance with the act of Congress establishing the bureau. The members of the committee are as follows: Prof. Elihu Thompson, of the General Electric Co.; Prof. E. L. Nichols, of the University of Chicago; Dr. Ira Remsen, President of Johns Hopkins University; Dr. Henry S. Pritchett, President of the Massachusetts Institute of Technology, and Albert Ladd Colby, Secretary of the American Association of Steel Manufacturers. The duties of the committee will be to visit the bureau at least once a year and report to the Secretary of the Treasury on the work accomplished and the condition of the equipment.

THE CAPE TO CAIRO TELEGRAPH is progressing steadily with the building of the railway between Mombasa and Victoria Nyanza; 480 miles of this line had been completed by last December and three wires were in use between Mombasa and Nairabi, a distance of 310 miles. A temporary line is in use between Railhead and Port Florence, the terminal of the Victoria Nyanza section, and from Port Florence to Entebbe the line is completed. Living trees are used for poles, since they are not attacked by the white ants, and tarred hempen cords are used for fastening the wires.

ered safe by the inspector of construction, at each end of the tunnel. If the inspector did not consider the temporary timbering safe, he could refuse to go in under it, during the construction of the permanent lining. A clause in the specifications required the presence of the inspector during the laying of the brick and concrete work, and the engineer could refuse an estimate unless the inspector was present.

For the most of the time this rule did not have to be enforced, as the contractors soon found that it was much cheaper to furnish sufficient timbering to hold the ground, than to have an accident.

There were many methods of temporary timbering tried in the west end, but the method most used was to advance the side headings for the concrete walls about 10 ft. and support the roof for about 8 ft. on the center core; supporting the latter, where necessary, by cross timbering to the side walls. The face of the center core was usually kept well under the finished brickwork, so that a slip of the material in front was easily avoided, the workmen becoming used to the warnings which the material almost always gave before anything of that kind occurred.

The price paid for this work was so unprecedentedly low in the history of tunneling, that the contractors could not be urged to take such precaution, as an engineer of a private corporation would naturally insist upon.

About 200 ft. of the west end of this tunnel was excavated of the full section, in 8-ft. lengths, without any support, but was lined with the concrete and brick, just as quickly as possible, as it was found that continued exposure to the air caused slaking and cracking, but in this part of the tunnel the material was very dry and firm, and the utmost vigilance was observed by the inspector, who was a tunnel foreman selected on account of his experience in this class of work.

Under Grand Ave. the ground encountered was more seamy, and had so many small veins of water that it was not only very disagreeable for the workmen, who had almost to become amphibious animals, but was very dangerous and difficult to handle. Fortunately, the greater part of the water came from the roof, so that the core remained dry, as soon as the top headings were driven, the water being conducted to the sides and pumped out from sump holes into a flume leading out to the portal. This ground had to be supported on lagging, and caps resting on plumb posts, which in turn rested on the core.

Very slow progress was made on this part of the work, and the fact that the tunnel was on a down grade from the west portal, made it much more difficult to keep the floor of the tunnel dry. The management on the part of one of the contractors who had immediate charge of this end of the tunnel was not as good as it might have been, but he made up in pertinacity for what he lacked in judgment, and, on the whole, did as well as most men who had never had experience in that class of work. The only fatal accidents in this tunnel happened in this end, six men being killed during the progress of the work. Three of these were killed in one land slide at the west portal, and two at different times by small slips from the sides and roof, one being killed in the approach cut, by falling on his own pick, which penetrated his brain through his eye. His fall was caused by a blow from a chunk of clay. A serious fall occurred in the east end, when the side drifts had been advanced about 150 ft. from the portal. The material up to this point had been a blue argillaceous sandstone, weighing about 130 lbs. per cu. ft. The material at this point, however, changed suddenly to a yellow clay, with seams of water, and this extended diagonally across the tunnel, and about half way down on the face. There is little doubt that there had been a considerable accumulation of water here from various sources; some may have been from old cesspools, some from leaky sewers and water pipes, and some from the natural seepage from irrigating lawns on Olive and Third Sts., above. The result, however, was a very heavy fall of this material, filling up the two side drifts for some distance back from the face of the excavation.

This fall was altogether too extensive to attempt any temporary timbering to hold it, and as there was danger that it might work back along the center line towards the portal, it was decided to complete the permanent lining of concrete and brickwork as quickly as possible up to this point. This was done, and when the lining reached this point the trouble commenced. It was soon demonstrated that the six-ring brick arch, which occupies the central portion of the roof, was not strong enough to hold up the immense weight above it, and the temporary timbering was crushed and broken in a most alarming way. The ground exhibited all the peculiarities of swelling earth, so familiar to experienced tunnel men, especially on this coast, where nearly all our material is composed of the clays, shales, and soft sandstones of the Tertiary period.

The phenomena exhibited by this material were most interesting, as showing that pressure is nearly always the cause of swelling ground in tunnels. The clay would be pressed down with such force that it would fold down over the timbers, in some cases as much as 6 or 8 ins., and in others, where it was held back by more lagging, it would crush posts into caps of Oregon pine as much as four inches. It acted just as a batch of bread ready for the oven would do, if it were taken from the doughpan, and supported on a dozen blocks of wood on the kitchen table.

The effect of this pressure on the end of the finished lining soon became apparent in the cracking of the brickwork, and the distortion of the arch, even to the extent of warping and twisting the heavy centering, which had not yet been removed. When this occurred, it was concluded to increase the thickness of the brick arch to nine rings of rowlock bond, instead of the six rings which the plans called for, and to continue this arching ahead, until all signs of pressure had disappeared. It was found necessary to continue this nine-ring arch for a distance of 80 ft. before the appearance of the ground justified a change to the original plan of six rings. Meantime, before this piece was completed, the six-ring arch continued to crack and show signs of distortion, but this ceased about the time the reinforced arch was finished, and remained in this cracked condition about five months, until the connection was made between the two ends, when it was decided to strengthen this part of the tunnel lining.

A careful examination of the brickwork developed the fact that the lower ring had separated from the second ring in places, and sometimes two of the rings had separated from the remainder, and in one instance this separation extended to the third ring.

To determine the actual distortion of the arch, a very ingenious little instrument was devised by Mr. Wolbrecht, the engineer in charge of the alinement, and by this means the actual shape of the arch for each 5 ft. was plotted to a large scale, so that the necessary adjustment and repairs could be made. The concrete walls had never shown any signs of weakness, and any plan for strengthening the arch had only to be applied to the brickwork. This simplified matters a good deal, and after mature deliberation it was decided to adopt a plan which was proposed by Mr. E. T. Wheeler, the writer's former assistant on the tunnel work. This was to insert steel concrete beams in the brickwork, at intervals of 4 ft., under the distorted arch, and when these were thoroughly set, to chip away all projecting brickwork between them, and replace all separated rings with strong concrete, bringing the entire inside surface of the arch as nearly to a true surface as possible, preparatory to plastering the entire interior surface of the tunnel lining. These beams, of which there were eleven in all, as shown by the profile, Fig 1, were 12 ins. wide, and from 8 to 12 ins. deep, according to the condition of the brickwork. They were made with a mixture of 1 part cement, 2 of sand, and 3 of small screened gravel, and each beam had inserted in it, two pieces of

FIG. 2. VIEW OF EAST PORTAL.

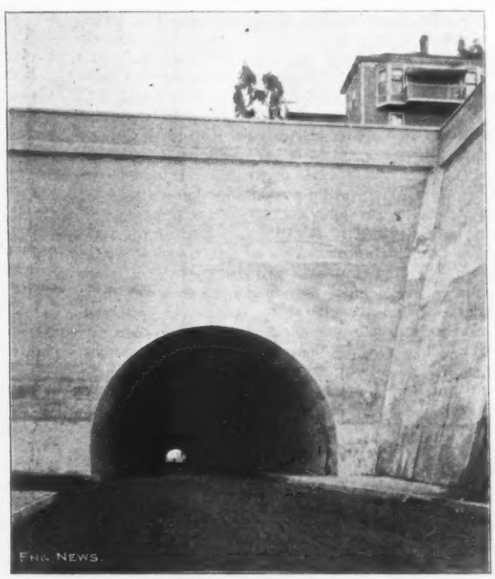

FIG. 3. VIEW OF WEST PORTAL.

THE THIRD STREET CONCRETE AND BRICK-LINED TUNNEL, LOS ANGELES, CAL.

By J. H. Quinton, M. Am. Soc. C. E.*

The Third Street Tunnel in Los Angeles, Cal., has probably given rise to more controversy and foolish talk amongst people, many of whom never saw a large tunnel before, than any other piece of work that has ever been done in that city.

The necessity for this tunnel arises from the fact that a large part of the city is cut off, on the west, from the business center, by some low hills which run out nearly parallel, and close to the main business streets. One of these hills is pierced by the Third Street Tunnel, which passes under Olive St., Grand Ave., Bunker Hill Ave. and part of Hope St. A plan profile and sections of the tunnel are shown by Fig. 1, while Fig. 2 is a view of the east, and Fig. 3 is a view of the west portal.

The east portal of the tunnel is about half way between Hill and Olive Sts., and the approach, 160 ft. long, is enclosed on the side with monolithic walls of concrete.

The west portal wall is on the center line of Hope St., and is 45 ft. high from the grade of the tunnel approach to a depth of 45 ft., this design was changed to the present one by the writer. The portal and retaining walls at the east end had to be changed also, so as to accommodate the property owners who had served an injunction on the city, because of some fancied advantage to one, and disadvantage to another. Things were finally arranged to the satisfaction of all parties, and the work of excavating the approaches was commenced early in 1899. The portal walls and retaining walls at the east end were finished before the end of that year.

During the time the excavation at the west end was being carried on, the sub-contractor for this part of the work was engaged in spending his profits in the construction of a digging machine, which he expected to shove through the hill (1,050 ft.) in just a few days. The machine was not enough of a success to justify me in giving a very detailed account of it, but for the sake of warning to the unwary engineer who might be tempted to try another one, a brief description will be given.

The main feature of this machine was a large vertical wheel, about 12 ft. in diameter, with eight or ten radial arms of Oregon pine fastened to the main shaft. The shaft rested on a frame-

The shaft of the machine, which ran lengthwise of the tunnel, was connected by suitable gearings to an electric motor, which received its power from the line of one of the power companies near by.

For boring a hole through cheese or chalk or some other homogeneous material, this would have been a most excellent machine, if only sufficient cheese or chalk could have been found to warrant the building of it, but after some weeks' experiments with the material in the Third St. tunnel, which was neither cheese nor chalk, but a very heavy argillaceous sandstone, with occasional nodules of limestone, the unhappy designer of his wonderful machine found himself and his machine—literally and metaphorically—"in a hole." The machine was some 80 ft. under the ground, and could neither go back, on account of the rails behind, nor forward, on account of the material which it had run up against, nor to the right, nor to the left, because the hole was just the size of the wheel, and after some days the machine was taken apart and consigned to the scrap heap.

The first hole started by the machine was on the south end of the tunnel, and was run in for a distance of 80 ft., about 12 ft. in diameter, and with-

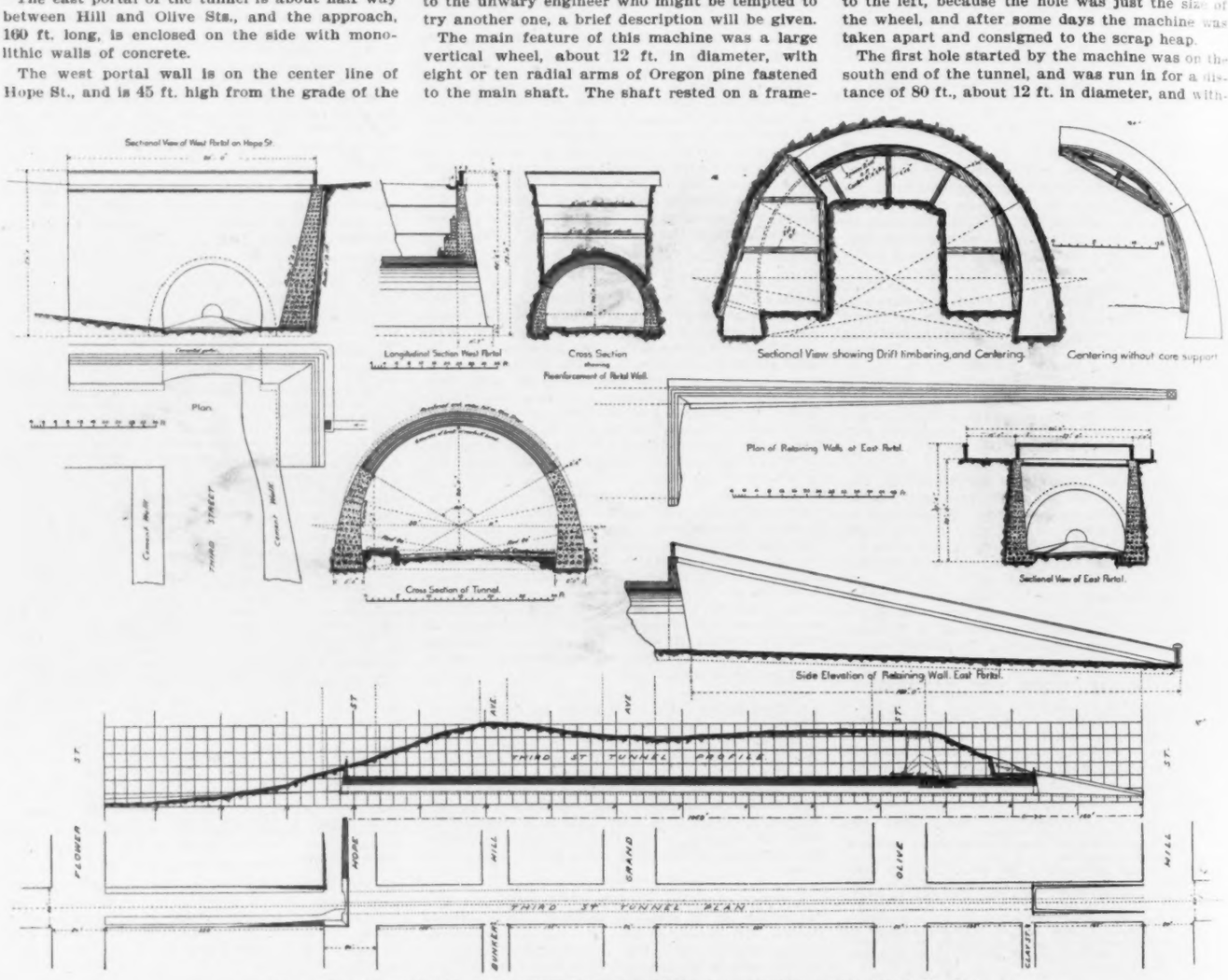

FIG. 1. PLAN, PROFILE AND SECTIONS OF THIRD ST. TUNNEL, LOS ANGELES, CAL.

Designed by H. P. Vincent, under J. H. Dockweiler, City Engineer. Constructed by J. H. Quinton, M. Am. Soc. C. E., under F. H. Olmsted, M. Am. Soc. C. E., City Engineer. Swenson & Hill, Contractors.

tunnel entrance to the upper level of Hope St. The parapet wall extends 4 ft. higher. The upper level of the west half of the street is held by a return wall, of the same section as the portal wall, and at right angles to it, and together they form a monolithic mass of concrete of a very substantial and imposing appearance.

The original design for this portal was for a straight wall about 50 ft. high, and 100 ft. long, running almost on the center line of Hope St. As there was no provision made for supporting the upper part of Hope St., where cut away in the

work supported on a small carriage, which ran on rails laid into the tunnel, as the machine ate its way into the ground. On the face of the radial arms of the wheel were fastened steel pick points, at such intervals as to make a continuous cutting the depth of the points, at each revolution of the wheel. The material was caught, as it fell from the face, by curved sheet iron buckets, which revolved with the wheel, and dumped their contents on a conveyor which ran to the back of the machine. This conveyor dropped the dirt into a car which ran out on a trestle to a convenient point for dumping into wagons and carts.

out any support whatever. Soon after the material was opened up, the effect of the air upon it was such as to necessitate its support with temporary timbering, until the permanent lining could be put in.

Here a weak spot in the specifications appeared. The city expressly disclaimed all responsibility for accidents, and made no mention of the method of temporary timbering to be employed. After due consideration of this matter by the city engineer, his chief deputy, and the writer, it was concluded to allow the contractor to use his own methods of temporary timbering, provided they were consid-

*Consulting Engineer, Los Angeles, Cal.

When this slide was cleared away it left a space about 40 ft., back from the wall, 60 ft. wide, and 22 ft. deep at the crown of the arch, to be filled with loose dirt after the arching was completed. As the wall was designed to stand against a bank of hard clay which had never been disturbed, and as the brickwork of the arch projected 2 ft. into the wall, which was at this height a little less than 6 ft. thick, it was concluded to reinforce it, as shown in Fig. 1. A blind drain was also laid back of the wall, as shown. As an additional precaution against the sliding of the theoretical wedge of earth, and consequent pressure against the wall while it was still green, two horizontal layers of redwood planks were laid in the earth as the fill was made, to break up this sliding wedge action against the wall. Great care was taken, in making this fill, to tamp and wet it thoroughly, and it was made as nearly as possible in horizontal layers of about 1 ft. in depth.

The sewer which crossed above the tunnel on Hope St., and which may have contributed by its leakage to the accident, was carried across the top of the portal wall, and down in the corner between the main and return walls in front to the level of Third St., where it connected with a main sewer.

This wall, although of much lighter cross-section than usually adopted for retaining walls for earth, has not shown any signs of settlement. Allowance must be made, however, for unusually favorable conditions of climate in Los Angeles, severe frosts being practically unknown, and rainstorms few and far between.

The work of lining this tunnel occupied one year, the contractors having received several extensions of time. It was turned over to the city and opened for travel on March 1, 1901. The original plans were made by Mr. H. P. Vincent, for Mr. J. H. Dockweiler, who was then city engineer. A few days after the contract was let, a new administration came into office with Mr. F. H. Olmsted, M. Am. Soc. C. E., city engineer, and the writer was engaged by him to superintend the construction of the tunnel. The cross-section of the tunnel was not changed, but some changes had to be made in the portals, for various reasons as mentioned before.

The alinement and grade was attended to by Mr. E. T. Wheeler, until his leg was broken by an accident in the west end, and afterwards by Mr. Wolbrecht, to both of whom much credit is due for extremely careful and accurate instrument work, and conscientious attention to their duties under many trying circumstances. The contractors for the work were Messrs. Swenson & Hill, of Los Angeles.

The alinement carried through from the east end struck the string of the plumb bob hanging in the center of the west portal, and the grades checked within 0.005 ft. Of course the distance was only 1,000 ft., but the results showed that the instrument work was very carefully done.

The Broadway tunnel, which is 8 ft. wider than the Third St. tuhnel, and is now nearing completion, was also in charge of the writer for Mr. Olmsted, and was under construction at the same time. The same assistants, and some of the same inspectors, were engaged on both tunnels, but the methods employed, and the results attained, were very different in the two tunnels. The Broadway tunnel, however, is another story, which will be taken up when the work is completed.

SUMMER MEETING OF THE AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS.

The midsummer meeting was held at the Victoria Hotel, Chicago, July 12 and 13, the President, Mr. J. H. Kinealy, being in the chair, and about 30 members and visitors present. The first session opened at 2.30 p. m., July 12, and after the calling of the roll and the announcement of the election of new members, Prof. R. C. Carpenter read a paper on "The Effect of Circulation on Firebox Heating Surface." The paper was very brief and described the preliminary experiments on an apparatus designed for the purpose, and which experiments are to be continued. The general results showed that the efficiency of the heating surface, or the conducting efficiency of the metal, increase with the velocity of circulation, showing the relation of circulation to boiler efficiency. The velocity was varied by forcing the water through the heating chamber, which surrounded the firebox by varying the head from which the feed was delivered. Several of the members criticised the design of the apparatus as not being representative of actual boiler practice, and several suggestions were made as to the apparatus and the future experiments.

A paper on "Hot Air Furnace Heating" was then read by Mr. C. G. Folsom, describing the equipment used in a residence, and the results obtained as to heating efficiency and coal consumption in this particular case. Prof. R. C. Carpenter then read a paper on "Test of Radiators with Superheated Steam," an abstract of which is as follows:

TEST OF RADIATORS WITH SUPERHEATED STEAM.

In making a series of radiator tests during the spring of 1901, superheated steam was inadvertently used in several cases, and to my surprise the capacity for heat transmission of the radiator was thereby reduced. Two radiators were tested: No. 1 was 18 ins. high, and contained 10 sections each 11 ins. wide, with very little air space, the least distance between sections being ¼-in.; No. 2 was 38 ins. high, and contained 10 sections, each 7 ins. wide, spaced so as to give abundant room for air currents, the least distance between sections being ¾-in. The radiators were both tested with steam which was taken through a single inlet. No. 1 was of the hot-water type, with top connection as well as bottom connection of the sections; No. 2 was of the steam-heating type with no top connection of the sections.

The writer has observed in previous tests of radiators that when testing a high and low radiator, the low radiator would always show a greater heat transmission for the same surface exposed. These tests showed an apparent exception to this rule, as the higher radiator gave a higher rate of heat transmission per sq. ft. of surface than the lower. An examination, however, of the dimensions of the radiators showed that the air space surrounding the sections in the low radiator was very much less than in the high. The air space per unit of surface in the high was probably about four times that in the low radiator. The test is interesting as showing that by properly proportioning the air space between the sections, the heat transmitted per unit of surface in high or low radiators may be equalized. This also shows that the air space doubtless plays an important office in carrying away the heat from the radiators.

The process of reducing the pressure resulted in wire-drawing the steam, thus liberating a considerable amount of heat energy which expended itself in superheating the steam, and the effect of this, contrary to our expectations, was to reduce the amount of heat transmitted. This is shown by the following tabulated results. Several check runs were made, the results of which showed a variation of less than 2%.

Steam press. lbs.	Superheat, degrees.	Heat transmission, B. T. U. Rad. No. 1.	Rad. No. 2.
..	0	1.48	1.83
..	36	1.16	1.41
5	13.1	1.41	1.74
5	24.1	1.23	1.45
10	0.3	1.50	1.90
10	26.7	1.24	1.62

The conclusions from the tests made with superheated steam would be that it is a poor medium to employ for heating purposes, the reason doubtless being due to the fact that superheated steam is much more nearly like a perfect gas in its nature than a saturated vapor, and when in this condition parts with its heat much less readily than saturated or wet steam. It is not probable that the amount of superheat was sufficient in any of the cases described to fill the entire radiator with steam of this character, and this I take it accounts for the continued falling off in heat transmission as the degree of superheat increased.

In the discussion, Prof. Carpenter expressed the opinion that to get the best results the inside surface of a steam radiator must be covered with moisture. The session concluded with a topical discussion on the question of architects furnishing plans and specifications for heating and ventilating equipment. At the evening session, Mr. Alvin D. Reed read a paper on "The Heating Systems in the Public Schools of St. Louis, Mo.," which was illustrated by lantern slides.

At the session on July 13, Mr. W. M. Mackay read a paper on hot-water heating apparatus, an abstract of which is given below:

VOLUME OF WATER IN HOT-WATER HEATING APPARATUS.

The volume of water required per square foot of radiating and heating surface in the radiators, mains and heater of a hot-water heating apparatus, for best results in heating, and greatest economy of fuel in operation, is a question which has received some attention, but we are still far from a standard, particularly in the volume of water required in the heater per square foot of heating surface exposed to the fire or heated gases. In the manufacture of radiators, particularly those for hot-water heating, the standard aimed at, and finally accepted, by the leading manufacturers, has been 1 pint of water per square foot of surface. This seems in practice to be the best suited for all classes of buildings, except perhaps those of glass construction. In such cases I have found it to be an advantage, on account of the greater and quicker cooling effect in such constructions, and the variable temperatures at which the water in the system is sometimes maintained, and on account of friction due to the long lines of piping usually employed, to use a surface that contained from 50 to 100% more water.

In an experiment in two greenhouses of the same size, with the ordinary 4-in. pipes, the pipe in one house had an internal area of about 10 sq. ins.; in the other house, oak strips 2 × 2 ins. were inserted in the center of the pipes (supported by projecting nails) reducing the waterway about 40%, while retaining the same external surface. In a six-hour test maintaining 60° in each house, with an outside temperature of from 25° to 30°, an average temperature of 160° was maintained on the flow mains and 130° on the return mains at each heater. The consumption of fuel was 130 lbs. of anthracite coal (stove size) for the house with full waterways in the radiation surface, and 110 lbs. of the same coal for the house with reduced waterways, while the temperature on the flow main on the heater with reduced waterways was frequently 5° higher than on the other heater. Since that time, I have used largely 1¼-in. pipe, with a little over 1 pint of water per square foot of surface, in small conservatories; 1½-in. pipe with about 1⅛ pints of water per square foot in conservatories of medium size, and 2-in. pipe with 1 quart of water per square foot, in large conservatories and greenhouses. This is in preference to 4-in. greenhouse pipe with about half a gallon of water per square foot of surface, and I have obtained better and quicker results, a greater possible variation of temperature, and greater economy from the use of 2-in. pipe with manifolds, than from any other size of pipe, either larger or smaller.

In arranging the mains of a hot-water heating apparatus, the area of the main has to be determined from the number of square feet of radiating surface to be supplied, and the nature of the surface (whether direct, direct-indirect, or indirect radiation), and from the length of the main; also whether the main is to be used as radiating surface, or covered. Therefore no standard as to volume of water per square foot of surface supplied, could be adopted in regard to the mains in a hot-water heating apparatus, without being subject to considerable variation. At the same time I have found cases where the area of the mains was from 25 to 50% larger than was necessary, being made large to ensure a uniform temperature in the main, which could have been obtained in a smaller main with a different arrangement of taking off branch connections.

The greatest difference of opinion as to the volume of water required per square foot of its surface, in hot-water heating, seems to exist in the heater, or source of supply. Boilers of the Cornish type which are used in some sections for hot-water heating, contain about 3 gallons of water per square foot of boiler surface; the ordinary horizontal and vertical tubular boilers arranged for hot water, have about 1½ gallons of water per square foot of surface; a number of cast-iron one-piece and sectional heaters have about one gallon of water per square foot of surface (some have 3 quarts, and others have half a gallon). Then some heaters of this latter type, and water-tube heaters, contain from 3 pints to 1 pint of water per square foot of surface, and in some heaters constructed of 1-in. pipe, while the volume of water per square foot of surface is not materially reduced, the friction is increased by inserting a sheet metal circulating division reducing the pipe to half its area. Now if we omit the Cornish boilers, which are more largely used in other countries, and commence with the horizontal tubular boiler, which is largely used in this country, we have a variation in hot-water heaters, of all the way from 1½ gallons to 1 pint of water per square foot of surface. I have obtained the best results from an average of half a gallon of water per square foot of heating surface in a hot-water heater, with an average of from 20 to 25 sq. ft. of heating surface to each square foot of grate area; the surface being arranged about 50 to 60% of fire surface, and about 40 to 50% of flue surface.

In the discussion, reference was made to the importance of the question of the relation of surface to volume, and Professor Carpenter stated that the efficiency depends largely upon the circulation. Mr. Thompson considered that many heaters contain a much greater volume of water than is desirable.

TOPICAL DISCUSSIONS.

In addition to the topical discussion already mentioned, some other subjects were brought up at this session and were briefly discussed.

"Life of Metal Air Ducts and Under What Conditions Can They Be Dispensed With."—Mr. Folsom said that some ducts enclosed in brick or tile were still in good condition after ten years' service, but metal is not advisable where liable to be damp, and the sheet steel now used rusts and pits more rapidly then the iron formerly used. He uses cement or brick for underground work. The use of brick and tile for flues was also referred to.

"Why Not Use Small Ducts, High Velocity and High Pressure in Ventilating Work."—Prof. R. C. Carpenter explained that the ordinary low-pressure system is not practicable for office buildings, on account of the size of ducts required. On some of the large passenger steamers on the Great Lakes a high-pressure system is used, with pipes 4 or 6 ins. instead of 10 or 12 ins. diameter. A baffler or hood on the mouth of the pipe distributes the air and prevents direct drafts.

"What is the Life of Wrought Iron and Steel Nipples in Cast-Iron Radiators."—The steel nipples are sometimes very much thinner than wrought iron, and become honeycombed in two years. Good steel nipples are as satisfactory as wrought iron, and there has been no trouble with malleable cast-iron nipples.

"What Has Been Your Experience with the Anemometer?"—This device has several times been criticised at meetings of the society, as being unreliable, no two anemometers giving comparable results. Each one has its own peculiarities and variations. Professor Carpenter, however, considered them reliable if properly used and tested. As to variations of the same anemometer when fitted to the same pipe or duct, it must be remembered that the velocity of current varies considerably at differents parts of the cross-section of the pipe.

This concluded the program and the meeting then adjourned. The annual meeting will be held in New York in January, 1902.

STATISTICS OF RAILWAYS OF THE UNITED STATES FOR THE YEAR ENDING JUNE 30, 1900.

An abstract of the annual report of the Statistician of the Interstate Commerce Commission for the year ending June 30, 1900, has been issued to the press, from which we take the following figures of most general interest:

MILEAGE.—On June 30, 1900, the total single-track railway mileage in the United States was 193,345.78 miles, an increase during the year of 4,051.12 miles being shown. This is a greater increase than that for any other year since 1893. The states and territories which show an increase in mileage in excess of 100 miles are Alabama,

steel, 3 × ¾-in. in section, extending from one concrete wall to the other. The steel ribs were set close to the soffit of the newly adjusted arch and seated on the top of the concrete walls in specially designed pedestals built of angles and plates.

The centering employed for this repair work was of a very substantial kind, as it looked like a hazardous business, chopping away 12 ins. of brickwork out of 26 ins. of thickness, under such an immense pressure as was apparent at this place. Strange to relate, however, there was not at any time enough weight on the centers to crush in the slightest degree any of the numerous blocks and wedges which held the brickwork on the centering, while the repairs were being made.

The work of chipping out the brickwork was very arduous, and proved that the brick arch had actually become a monolith of inferior concrete. I say inferior, because bricks made on this coast cannot compare in strength with those made in the eastern states, but the mortar was excellent, and formed fully one-third of the mass of brickwork, so that it was a difficult matter to chip it. The mortar was composed of 1 part of lime paste, 2 parts cement, and 8 parts of sand by measure. The lime was added to the mortar in order to retard the setting, and make the mortar more plastic, and certainly the results attained in the brickwork have been most gratifying. The lime and sand were both of the very best quality. The cement used is a local product, and gives higher tests than any of the imported Portland cements.

The only crack in the concrete walls of this tunnel, so far as the closest examination could detect, was found at the place where the last 8-ft. section of the six-ring arch joined on to the nine-ring arch. This crack was caused, evidently, by the immense weight concentrated on, and near the end of this eight-foot section, before it was connected to the first section of the nine-ring arch, and while it was still green. After the latter was built, the pressure was still so great as to deform the nine-ring arch to some extent, but this action ceased after a few weeks, and all the inequalities were adjusted after the steel concrete beams were put in place and allowed to harden.

There has, as yet, been no sign of any further settlement at this place. It is reasonable to suppose that if settlement has ceased, when the concrete and mortar are yet green, it is not likely to take place again, because the supporting material grows stronger as it grows older. When the nine-ring arch had been carried forward some 20 ft., the end of this fall became apparent in two chimneys, one on each side of the tunnel extending upward about 30 ft.

These holes had evidently been working and caving in at the top for a long time, and as they were now in such a dangerous condition, it was decided to secure them just over the arch, with heavy timbering, and allow them to work to the surface. This was done and the nine-ring arch built ahead some 60 ft. These holes continued caving and apparently came together, reaching the surface 60 ft. above, on Olive St., about three months after the arch was completed. The hole on the surface was elliptical, about 30 ft. in diameter, at right angles to the tunnel, and about 40 ft. lengthwise of the tunnel, and 6 ft. deep, as shown on the plan and profile, Fig 1. It required about 250 wagon loads of earth to fill it, and this may settle a little more at the surface as it is exposed to the winter rains.

Here is an instance of the difficulty of calculating with any degree of exactness on the forces to be encountered in tunneling. This hole did not run vertically to the surface, but inclined slightly forward in the direction the tunnel was being run, as shown by dotted lines on the profile. The two chimneys at the arch below were small, not to exceed 6 ft. square each, and apparently ran up to an apex. They were evidently where the fall had separated from the more solid material of the hill. The continuous settling and falling of the clay above this fall for three months, must have brought an immense weight on the arch. But who can say just how much?

Assuming the entire weight of the material above the arch at this place, acting as a uniform load, normal to the outside of the arch, would give 270 lbs. pressure per sq. in. on the brickwork, and this is as much as it ought to be subject to. On any other supposition the arch would certainly fail, either from the lines of pressure passing too far inside the intrados, or from settling of the foundation, which would be very much overloaded.

If the line of pressure passes inside the intrados, the result would be a crushing and slivering of the brickwork near the haunches, and a tendency to separate the lower ring from the remainder of the arch. It is believed that the concrete beams, with the steel ribs at the soffit, will prevent this action. As the concrete walls were well tamped and practically incorporated with the surrounding earth all the way up, it hardly seems possible there could be a vertical settlement of the entire structure at this place so as to bring the weight of all the material above on the foundations. Either the entire lining of the tunnel must settle from end to end, or the portion subjected to the greatest weight must be sheared across in two places. This would be immediately detected by the cracks and displacement of the lining, and such action has never been observed.

Fortunately, the yellow and soft material encountered in the roof did not extend more than about half way down the face, so that the foundations were excavated in hard material, and unless this immense weight should have sufficient force to press the hard material up in the floor of the tunnel, it is probable that there will be no further trouble. The concrete walls are each 5 ft. thick at the base, and the material of the foundation is a blue, clayey sandstone, weighing about 130 lbs. per cu. ft.

Many seams and nodules of hard, blue limestone were encountered in this material, and several rare fossil shells, sharks teeth, and other relics of past life were found. Mr. Hamlin, the chief deputy for the city engineer, secured many of these specimens, and sent them to the Smithsonian Institution for naming, with the result that one was named "Lima Hamlini," being an entirely new fossil (although so very old).

The contract price for all the work on this tunnel was $88,449, and allowing fair unit prices for all the material in place, it was found that the most that could be allowed for excavation was 50 cts. per cu. yd. This would be a fair price for such material in an open cut, where it did not have to be hauled too far through the city streets, but for a hole in the ground, and taken out accurately all around, with the necessity for strong timbering, with risks of tunneling considered, this price was a little startling.

Every effort was made by the contractors to cheapen the work of excavation, and two digging or excavating machines were tried during the progress of the work. One of these, as we have seen, was consigned to the boneyard, early in the game, and the other, although a much more substantial and ingenious piece of mechanism, shared the same fate after a few weeks' trial.

This machine consisted of a revolving cylinder, about 1 ft. long and 6 ins. diameter, with steel points or knives all around its outer surface, traveling up and down a long arm, which was practically a radius of the outer circle of the excavation, and could be swept over the entire face of the tunnel. The cutter was made to revolve at a high rate of speed by an electric motor, and cut the material into little pieces about the size of saratoga chips. If a potato huge enough could have been found for this machine to work upon, no doubt it would not have been necessary to consign it to an early grave. Unfortunately, even California could not produce so large a tuber as this, and the machine had to go.

The machine would cut, but was too slow to be practicable, and, moreover, it required too much of the roof to be left unsupported, always a dangerous proceeding in tunneling in anything but firm hard rock; for the first principle of tunneling is like the first principle of making money: "hold what you get."

A return was then made to the old reliable method of picks, gads, shovels and elbow grease. It was very difficult to get even common laborers, for the west end of this tunnel, as not only had the accidents given it a bad name, but it was a most disagreeable and unhealthful place to work for a great part of the time, on account of the water. Skilled men, except brick masons, there were none, and this end of the tunnel was excavated and timbered by common laborers under the direction of the inspector, who was an experienced tunnel man.

The stratification in this material was not well marked, but occasionally beds were found which gave a strike of N. 75° W. — dip S. 15° W.

The exposed surfaces of tunnel and lining walls were plastered with a mixture of cement, sand and lime paste, in the proportion of 1 cement, 1 lime paste, and 4 of sand by measure. This mixture was found by experiment to give the best results.

The concrete used in the walls of the tunnel was specified as follows:

> One barrel of Portland cement, in the packed condition in which it is sold, to six (6) barrels of the same of the aggregates, i. e. sand, gravel and broken stone, shoveled full, but not otherwise compacted.

The contractors claimed that this meant six barrels of the aggregate, when mixed, and as some of the bidders so understood the matter, the claim was allowed.

As this was a very strong concrete for such thick walls, and as it is always a difficult matter to get a good connection between the different horizontal layers of concrete, the contractors were allowed to use a small proportion of large clean granite boulders, which were placed carefully by hand at the top of each layer, and sunk half their diameter in the concrete, when it was still soft. When the next layer was deposited, these boulders served to lock the two courses together, and in addition, added by their extra weight to the stability of the walls. The size of these boulders was graded to the thickness of the walls, some of those in the foundation course being as heavy as one man could handle. None were set nearer than 6 ins. to the face of the wall, or to each other. Although this arrangement was a manifest advantage to the contractors, it was difficult at times to get them to furnish the boulders in sufficient quantities to fulfil the purpose intended.

This practice has been severely criticised, but like many other practices, it is not the use, but the abuse of it, which is to be condemned. Boulders were first used by the writer for making concrete walls for canals, and other structures for holding water. A little consideration will show that if one-half of a concrete wall is made up of large boulders of granite, this wall will not be so permeable to water as one made wholly of concrete mortar. We see this practice in large dams, where immense blocks of stone are imbedded in the concrete, and such dams are much more likely to be waterproof than if composed entirely of small broken rock concrete. Of course the danger of this practice lies in the abuse of it, by the contractor, in throwing the boulders into the wall promiscuously, but on this work there were two inspectors on each end of the tunnel, one to see the concrete and mortar mixed, and the other, who was a mason, to see it laid in the walls.

The specifications called for a roadway of asphalt, with asphalt concrete base, to be laid in this tunnel, but so much more water than was expected was developed, that it was concluded to substitute 8 ins. of decomposed granite which packs well, and makes a fairly good roadway in this climate. An additional reason for this change, and one which probably had some weight with the councilmen, is that there will probably be conduits, sewers and pipes, and perhaps a street-car line, through this tunnel some time, and if the pavement was of a more permanent nature it would probably be torn up again, and ruined before two years. Meantime the tunnel will be drying out, and if the roadway has to be torn up, it will not be an expensive matter. If, as appears probable, the water dries up in a year or two, and after all the pipes, etc., are laid, then the floor of the tunnel can be paved with asphalt on a concrete base, the same as the east approach.

The reinforcement of the west portal wall, as shown by Fig. 1, was considered necessary on account of a serious landslide which happened there before the tunnel lining had been connected with the wall. This slide occurred without any warning, and killed three men, one of them an inspector, and entombed eight men who were working inside. The latter were relieved in about twenty hours, none of them hurt, but naturally scared.

less be in these areas. The available rainfall records extend back to 1885, while records of severe storms are in existence to 1861. These records show that the heaviest storm—that of Oct. 12, 1874, lasted 2½ hours, and in this time 5.25 ins. of rain fell; an average of 2.10 ins. per hour. Other storms of 2 ins. per hour for 45 m., 2.40 ins. for 5 m., and 2.32 ins. for 15 m., are recorded. At the U. S. Weather Bureau Station there is a record of 3.07 ins. per hour for 10 m., and 2.75 ins. per hour for 23 m.

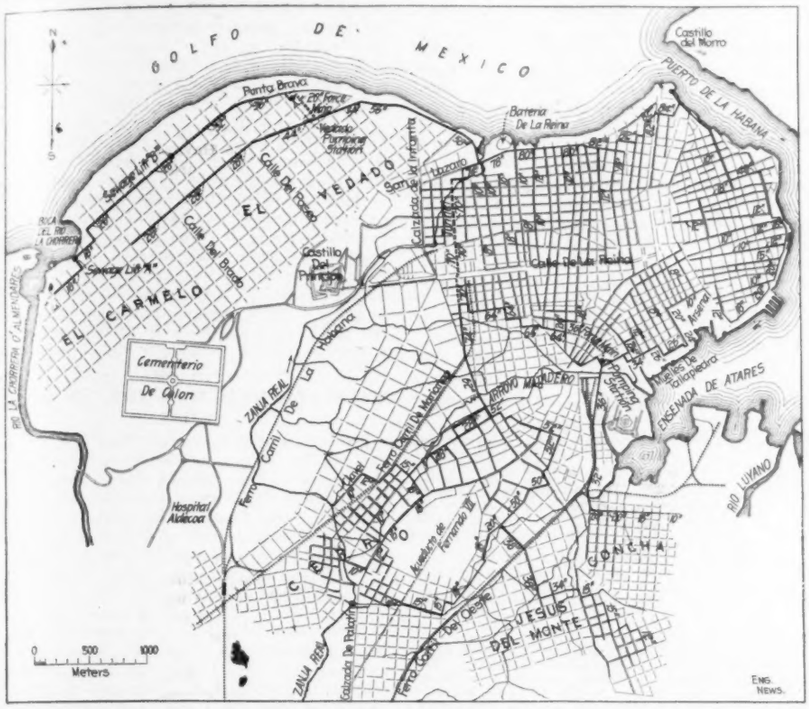

FIG. 1. GENERAL PLAN OF THE PROPOSED SEWERAGE AND DRAINAGE SYSTEM OF HAVANA, CUBA, SUBMITTED BY SAMUEL M. GRAY, M. AM. SOC. C. E., CONSULTING ENGINEER.
(Only the Main Sewers are shown here. Laterals 8 to 12 ins. in size are omitted.)

After carefully studying prevailing conditions and describing the various later methods of drainage and sewerage disposal, Mr. Gray recommends the Separate System as the most economical and best adapted to the needs of Havana. He also recommends final disposal at a point about 3,500 ft. east of El Morro, at substantially the same point suggested by Mr. D. E. McComb, of Washington, D. C., who had also submitted a report upon Havana sewerage. The sewage was to be discharged 600 ft. from the shore, without any previous treatment. The main pumpage station was to be located on the east side of the harbor, near El Morro; and the sewage was to be concentrated at La Punta, on the west side, and taken across the harbor in submerged masonry pipes to the pump well. From the latter it would be lifted by the pumps to the main outfall sewer, which would be partly in tunnel and partly in open cut, to the point of discharge. Provision should also be made for eventually taking into the general system all the sewage from the suburban districts.

The elements of design in the system proposed are given as follows: Storm water drains should be designed to dispose of water falling at the rate of 2.50 ins. per hour, and Mr. Gray gives his reasons in full for this recommendation. The sewers are designed on Kutter's formula, with n = .014 for all brick sewers, and .013 for all pipe sewers; all sewers flowing half full, with velocities of not less than 3 ft. per second. The storm water drains would be generally circular, and may run full under maximum conditions, discharging either into the harbor or gulf.

The sewerage system is designed on a basis of 200 persons per acre, in the old part of the city, and 80 persons in the suburban parts. For maximum flow an allowance is made of 150 gallons per head for 24 hours, with 50% additional (making a total of 225 gallons per head). For ground water reaching the sewer, an allowance of 150 gallons per acre per day is made. The entire system would provide for a future population of 600,000; and the maximum sewage and ground water capacity of the system would be 138,000,000 gallons per day. The general plan for collecting the sewage is somewhat similar to that outlined by Mr. McComb in his report; with the exception that Mr. Gray's report contemplates the sewerage of certain districts not considered by Mr. McComb. The accompanying map shows the marginal, or intercepting sewers, leading to La Punta, and covering the old city. In the southern section of the city, near Matadero Creek, is a low system from which the sewage will have to be lifted into the gravity system. This district covers about 290 acres in the old city, and 460 acres south of the creek. To collect the sewage from the higher parts of El Vedado, a high level sewer is designed, which may be extended westward as the demands arise. To collect the sewage from the other parts of El Vedado and El Carmelo, lying on a long level coast, a series of lifts would be necessary, with small pumping stations, operated by electric motors. The disposal of sewage from Regla and Casa Blanca is also considered, though sufficient data is wanting to design complete systems for these suburbs.

The general system of sewerage would eventually have four pumping plants and two sub-lifts, as shown on the plan. The main pumping station at El Morro would have to lift 138,000,000 gallons in 24 hours, with a population of 600,000; and the total lift at this point would be 23.3 ft. To do this work four 36,000,000-gallon pumps are required, with a boiler capacity of 600 HP., including reserve power. The plan for the conduit across the harbor contemplates the use of two inverted siphons, 5 ft. in diameter, made of three rings of brick masonry inclosed in steel riveted pipe. These siphons would be built in sections, about 20 ft. long; fitted with cast-iron flanges at each end and closed with bulkheads. They would be then floated to place, sunk in trenches provided, bolted together, and the bulkhead would then be removed by a diver, the whole plan of operation being similar to that adopted in the case of a similar pipe laid across Shirley Gut, for the Metropolitan sewerage system of Boston. The shore ends of the siphons would be built in a 7-ft. tunnel about 200 ft. long; and from the ends of these tunnels the two 5-ft. pipes would be laid and completely covered in trenches cut in the bottom rock for this purpose, and extending across the harbor entrance. At the present time only one of these 5-ft. pipes need to be laid, and only half the pumping plant need be installed.

The force-mains would be two 5-ft. diameter, riveted steel pipes, laid in 100-ft. lengths, though only one is now needed. The outfall sewer from El Morro would be 7 ft. diameter, built of concrete with a brick invert; the tunnel section would be 1,480 ft. long, and the open cut, 2,250 ft. This outfall sewer would discharge into a well built about 100 ft. back of the shore line; and from this well two cast-iron pipes would extend 600 ft. beyond the shore line.

The south side low district pumping station will ultimately lift 21,375,000 gallons per day a vertical distance of 21 ft. This would require three 8,000,000-gallon pumps, with 225-HP. boilers. Though only two pumps and boilers would be required at present. The force-main would be 36 ins. in diameter. The Vedado pumping station would finally handle a maximum of 8,025,000 gallons per day, lifted 16½ ft. Each of the sub-lifts should have a capacity of 2,500,000 gallons per day, lifted 9.15 ft.

No sewer less than 8 ins. diameter, and no drain less than 12 ins. diameter would be laid. The house connections would be 6-in. pipe; all manholes on the separate system would have tight covers and the sewers would be ventilated through the house connections and standpipes, carried to the roof on the outside of buildings.

The estimated cost of this work is as follows:

Drainage system	$574,090
Matadero Creek system	299,805
Sewerage system	3,108,897—$3,982,792

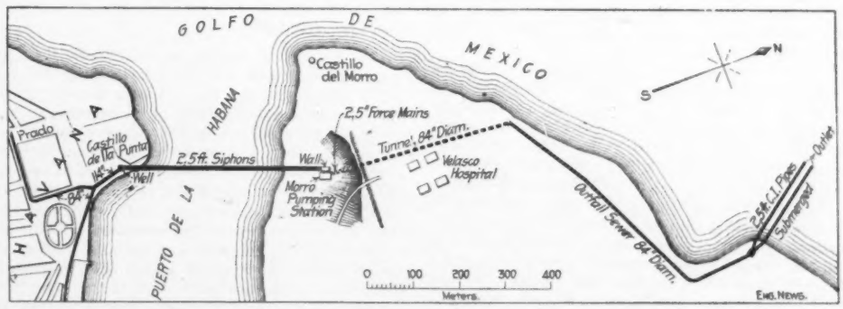

FIG. 2. PLAN, SHOWING THE PROPOSED LOCATION OF THE MORRO PUMPING STATION AND OUTFALL SEWER, FOR THE HAVANA SEWERAGE SYSTEM.

The estimated value of the works not needed at once amounts to $709,081, leaving $3,273,710 as the cost of building a system ample for the present time. In making this report, Mr. Gray acknowledges the valuable services of Mr. R. H. Keays, C. E., and the value of the report made by Mr. D. E. McComb, M. Am. Soc. C. E., Superintendent of Sewers, of Washington, D C. The appendix to the report covers detailed estimates of the various systems and plants.

Arkansas, California, Idaho, Illinois, Iowa, Louisiana, Minnesota, Mississippi, Nebraska, North Carolina, Oregon, Pennsylvania, South Carolina, Texas and Oklahoma. The aggregate length of railway mileage, including tracks of all kinds, was 259,788.07 miles. The distribution of this aggregate mileage was as follows: Single-track, 193,345.78 miles; second track, 12,151.48 miles; third track, $1,094.48 miles; fourth track, 829.29 miles; and yard track and sidings, 52,367.04 miles. The operated mileage of roads merged, reorganized, or consolidated during the year was 9,546.90 miles. The corresponding figure for 1899 was 5,846.35 miles.

EQUIPMENT.—There were 37,663 locomotives in the service of the railways on June 30, 1900, or 960 more than the year previous. Of the total number reported 9,863 are classed as passenger locomotives, 21,596 as freight locomotives, 6,621 as switching locomotives, and 583 are not classified. The total number of cars of all classes in the service of the railways on the same date was 1,450,878, an increase of 74,922. Of the total number, 34,713 are assigned to the passenger service, 1,365,531 to the freight service, and 50,594 to the direct service of the railways. Cars owned by private companies and firms and used by railways are not included. It appears that the railways of the United States used on an average 20 locomotives and 753 cars per 100 miles of line; that 58,488 passengers were carried, and 1,626,179 passenger miles accomplished per passenger locomotive; and that 51,013 tons of freight were carried and 6,556,731 ton miles accomplished per freight locomotive. All of these items show an increase when compared with corresponding figures for the year 1899. There was also a decrease in the number of passenger cars per 1,000,000 passengers carried, and a decrease in the number of freight cars per 1,000,000 tons of freight carried.

Both locomotives and cars being embraced in the term equipment it appears that the total equipment of the railways on the date referred to was 1,488,501. Of this number 1,005,729 were fitted with train brakes, the increase in this item being 197,655, and 1,404,132 were fitted with automatic couplers, the increase being 266,413. Practically all locomotives and cars in the passenger service were fitted with train brakes, and of 9,863 locomotives assigned to that service 7,431 were fitted with automatic couplers. Nearly all passenger cars were fitted with automatic couplers. With respect to freight equipment, it is noted that nearly all freight locomotives were equipped with train brakes and 75% of them with automatic couplers; the corresponding figure one year previous was 45%. Of 1,365,531 cars in the freight service June 30, 1900, 920,405 were fitted with train brakes, and 1,307,559 with automatic couplers.

EMPLOYEES.—The number of persons employed by the railways of the United States, June 30, 1900, was 1,017,653, or an average of 529 employees per 100 miles of line. As compared with the number employed on June 30, 1899, there was an increase of 88,729, or 34 per 100 miles of line. From the classification of these employees it appears that 42,837 were enginemen, 44,130 firemen, 29,957 conductors, and 74,274 other trainmen. There were 50,789 switchmen, flagmen, and watchmen. Disregarding 8,394 employees not assigned to the four general divisions of employment, it is found that the services of 36,451 employees were required for general administration; 321,946 for maintenance of way and structures; 197,799 for maintenance of equipment, and 450,063 for conducting transportation. During the year ending June 30, 1900, $577,264,841 were paid in wages and salaries, an amount $131,756,580 in excess of that paid during the fiscal year 1895. The compensation of the employees of railways for the fiscal year 1900 represents 60% of the operating expenses of the roads and 39% of their gross earnings.

CAPITALIZATION AND VALUATION.—The amount of railway capital outstanding June 30, 1900, was $11,491,034,960. This amount assigned to a mileage basis represents a capitalization of $61,490 per mile of line. Of this amount $5,845,579,593 existed in the form of stock. The funded debt was $5,645,455,367. The amount of current liabilities not included in the foregoing capital statement was $594,787,870, or $3,183 per mile of line. The amount of capital stock paying no dividend was $3,176,609,698, or 54.34% of the total amount outstanding. The amount of funded debt, excluding equipment trust obligations, which paid no interest, was $378,937,806. The amount of dividends declared during the year was $139,597,972, which would be produced by an average rate of 5.23% on the stock on which some dividend was declared.

PUBLIC SERVICE.—The number of passengers carried during the year was 576,865,230, showing an increase for the year of 53,688,722. The number of passengers carried one mile—that is, passenger mileage—was 16,039,007,217, there being an increase in this item of 1,447,679,604. There was an increase in the density of passenger traffic, as the number of passengers carried one mile per mile of line in 1900 was 83,295, and in 1899 77,821. The number of tons of freight carried during the year was 1,101,680,238, an increase of 141,916,655 being shown. The number of tons of freight carried 1 mile—that is, ton mileage—was 141,599,157,270. The increase in the number of tons carried 1 mile was 17,931,900,117. The number of tons carried 1 mile per mile of line was 735,366. These figures show an increase in the density of freight traffic of 75,801 tons carried 1 mile per mile of line.

The average revenue per passenger per mile for the year nding June 30, 1900, was 2.003 cts. For the preceding year it was 1.925 cts. The revenue per ton of freight per mile was 0.729 ct., while for 1899 it was 0.724 ct. An increase in earnings per train mile appears for both passenger and freight trains. The average cost of running a train 1 mile increased nearly 9 cts. as compared with 1899. The percentage of operating expenses to earnings shows a small decrease as compared with the preceding year.

EARNINGS AND EXPENSES.—For the year ending June 30, 1900, the gross earnings from the operation of the railways in the United States, covering an operated mileage of 192,556.03 miles, were $1,487,044,814, being $173,434,696 more than for the preceding fiscal year. The operating expenses were $961,428,511, the increase in this item being $104,459,512.

The income from operation, or amount of gross earnings remaining after the deduction of operating expenses, generally designated as net earnings, was $525,616,303, an increase as compared with the preceding year of $68,975,184. The average amount per mile of line for the year ending June 30, 1900, was $2,729, and for 1899, $2,435. The amount of income received from sources other than operation was $162,885,071.

Disregarding taxes paid to the United States Government under the recent internal-revenue act and small amounts not apportioned by states, there accrued against the railways of the United States during the fiscal year in question taxes to the amount of $47,415,433, or an average tax of $254.78 per mile of line.

RAILWAY ACCIDENTS.—The total number of casualties to persons on account of railway accidents during the year ending June 30, 1900, was 58,185. The aggregate number of persons killed in consequence of railway accidents during the year was 7,865, and the number injured was 50,320. Of railway employees 2,550 were killed and 39,643 were injured. The casualties to employees resulting from coupling and uncoupling cars were: Number killed, 282; injured, 5,229. The corresponding figures for the preceding year were: Killed, 260; injured, 6,765.

The number of passengers killed during the year was 249, and the number injured 4,128. The corresponding figures for the previous year were 239 killed and 3,442 injured. In consequence of collisions and derailments 88 passengers were killed and 1,743 injured. The total number of persons, other than employees and passengers, killed was 5,066; injured, 6,549. These figures include casualties to persons classed as trespassers, of whom 4,346 were killed and 4,680 were injured. The total number of persons killed at highway crossings was 750, injured 1,350. The summaries giving the ratio of casualties show that 1 out of every 399 employees was killed, and 1 out of every 26 employees was injured. One passenger was killed for every 2,316,648 carried, and 1 injured for every 139,740 carried. Ratios based upon the number of miles traveled, however, show that 64,413,684 passenger-miles were accomplished for each passenger killed, and 3,885,418 passenger-miles accomplished for each passenger injured. The corresponding figures in these latter ratios for the year ending June 30, 1899, were 61,051,580 and 4,239,200 passenger-miles for each pasenger killed and each passenger injured, respectively.

One summary shows that in the course of thirteen years ending June 30, 1900, in consequence of railway accidents, 86,277 persons were killed and 469,027 persons were injured. The injuries reported varied from comparatively trivial injuries to those of a fatal character. The casualties for the period mentioned occurred to persons as follows: Employees killed 38,340, injured 361,789; passengers killed 3,485, injured 37,729; other persons (including trespassers) killed 54,452, injured 69,509.

THE RESTORATION OF THE STEAM ENGINEERING Corps, as a distinct branch of the U. S. Navy, will be strongly advocated in the next Congress, according to Washington reports. The merging of the Engineer Corps into the line, under the late Personnel Bill, is said to fail in practice, and the lack of trained engineer officers may work incalculable harm to the service.

COSGRAVE ARMOR PLATE, made after the process invented by S. A. Cosgrave, of Pittsburg, Pa., was tested at Indian Head on July 2. The test plate was rolled from a 26,000-lb. ingot into a sheet 7 ft. long, 5 ft. wide and was 6 ins. thick, with 2 ins. highly carbonized steel, backed by 4 ins. of soft steel. At a range of 320 ft., 100-lb. projectiles from a 6-in. gun were fired at this plate, with initial velocities of 2,011, 2,019, 2,011 and 1,490 ft. per second. The plate was penetrated, as was expected, with this projectile; but no shot cracked or broke the plate. The shots fired at 2,011 and 2,019 ft. per second were broken into pieces. The low velocity shot was intended to stick in the plate, to test the effect of vibration on the plate. It did stick in the plate, but no cracks were apparent. The difference between the Krupp, the Harvey and the Cosgrave processes, is that while the first two processes only harden the face to a maximum depth of 1½ ins., the Cosgrave plate can be made of any thickness of absolutely uniform hardness. A 10-in. plate is soon to be rolled, carbonized to a depth of 4 ins.

THE DRAINAGE AND SEWERAGE OF HAVANA, CUBA.

From the full report of Mr. Samuel M. Gray, M. Am. Soc. C. E., and Consulting Engineer for the government at Havana, an abstract is made showing the plans submitted for the drainage and sewerage of Havana, Cuba. This report is dated June 5, 1900, and was presented to Mr. P. H. Cunningham, Chief Engineer of Havana, in accordance with orders received from Gen. Ludlow, Engineer Corps, U. S. A., the former commander of the Department of Havana, and Col. W. M. Black, Engineer Corps, U. S. A., Engineer of the Department of Havana.

The topographical and geological conditions are first set forth as follows: The City of Havana is situated on the north shore of the Island of Cuba, at the entrance to Havana harbor. The old part of the city covers an area of about 1,400 acres to the west of the harbor, and is thickly populated, with generally narrow and closely built-up streets; the only uncovered portions being small patios, or courtyards. The suburban districts cover about 3,750 acres; with a large part still open and unimproved, but some parts thickly populated, as in Jesus del Monte and Cerro. More than half of this total area drains naturally into Havana harbor; with the remaining parts draining to the north into the Gulf of Mexico, and to the west into the Almendares River. The harbor covers about 1,500 acres, and is from 30 to 50 ft. deep in the channel through the entrance; in the upper part of the harbor the depth is much less. This harbor receives the drainage of about 26 sq. miles, contributed by several small streams. The mean rise and fall of tide is about one foot.

The material underlying the city is largely composed of limestone and coral rock, lying from 2 to 10 ft. below the surface of the ground. This rock is of a porous nature, and probably does not contain much ground water above the elevation of tide. A ridge, about 40 ft. high above tide, runs east and west through the old city, with the northern slope draining towards the gulf, and the southern slope draining into the harbor. As a rule, the topography throughout the entire city affords good natural grades for the drainage of surface water; and in some portions of the suburbs the ground lies 120 ft. above tide elevation.

The present water supply of Havana is pure and abundant; the water being obtained from springs in the Vento hills, 8 miles distant. This is brought to the city by an aqueduct and distributed by an iron pipe system. The quantity is stated to be 35,419,000 gallons per day, or 173 gallons per capita.

Havana has never had a systematically-designed system of drainage or sewerage. In the old part of the city stone drains, built of rectangular blocks of coral rock, have been constructed; but they are made in such a way as to be deficient for sanitary purposes, and of little value in removing storm water from the streets. These drains receive the sewerage from houses and the overflow of cesspools, and discharge into the harbor or the gulf, as the case may be. As they are unlined on the bottom, this foul liquid must soak into the soil; and as the interior of the drains is rough and uneven, and as they were laid without proper grades, a large amount of filth is retained within them, to putrefy and give off at the inlets odors which are both disagreeable and detrimental to health. The catchbasins and inlets are without traps, and the sewers are only ventilated through the inlets. In the more thickly settled parts of the suburbs there are no sewers or drains, the gutters adjoining the sidewalks being used for conveying away the liquid wastes. Many of the small streams were used as sewers, and were thus extremely dangerous to public health. The U. S. military authorities, however, after the American occupation, took every possible precaution to prevent the fouling of these streams by cleaning and disinfecting them at frequent intervals, and also by keeping the streets scrupulously clean.

The present population of Havana is about 217,000, with 188,000 in the old part of the city. In some parts of the city the density of population is 246 persons to the acre; the general average of the more thickly settled area being 125 to the acre. In the suburban portions the average is now 7 to the acre; but future growth will doubt-

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The subject of train resistance on curves started a brisk discussion at the May meeting of the New York Railroad Club, and we have reprinted some of the fruitful parts of it on another page of this issue. A notable feature of the discussion was that an erroneous theory concerning train resistance was set forth in the paper, and found general support among the members present. Its essential falsity was finally shown by Prof. Lovell, of Columbia University. Since this error is one into which many engineers have fallen, it may be as well to explain it here.

Suppose a locomotive is pulling a long train of freight cars around a sharp curve. To one watching such a train, it seems as if the tendency must be for the pull of the locomotive to crowd the cars against the inner rail of the curve, and the longer the train, the greater this tendency, like the pull on a rope passed around the trunk of a tree. The author of the paper referred to claimed that this condition of things actually existed, and that one reason why a larger train load could be hauled in large capacity cars than in cars of small capacity was that the longer trains acted like a longer rope around a snubbing post, and set up a much greater train resistance in rounding curves. Undeniably this theory appears to be plausible. In rounding a sharp curve the locomotive may be moving at right angles to the direction in which the caboose at the rear is moving. Why, then, does not the train of cars act like the rope, and bind against the inner rail of the curve?

The main reason why it does not do this is that every car of the train tends to run in a straight line, and has to be forced to move in a curve by the guiding action of the outer rail on the flange of the front outer wheel of every truck. The obliquity of traction tends, indeed, to pull every car truck against the inner rail, but this force is so very trifling compared with the force tending to cause the car to move in a straight line, that it can hardly be considered of practical importance. So far as it exists, its only effect is to minutely increase the centripetal effect due to the superelevation of the rail. One reason why confusion of thought has existed on this point is that one considers the difference in angular direction between the first and last cars of the train; whereas actually it is the angle between two adjacent cars which determines the obliquity of traction. On a 10° curve, for example, the line of traction between two 30-ft. cars will only be deflected about 3° from a straight line, and it can be seen at once how very slight a lateral force this small deflection could cause.

It cannot be too often insisted upon that in handling inflammable oils in connection with manufacturing processes extreme caution pays; and this is especially the case where the oils are of a volatile nature. We find in the monthly bulletin of the Boston Manufacturers' Mutual Fire Insurance Co. an account of a recent fire at the Schenectady Works of the General Electric Co., which illustrates how even the most dangerous liquids may be handled with comparative safety and a fire, when it occurs, may be closely confined. We print the account as follows:

> At 10:15 a. m. fire occurred in one of the brick dipping cells in building No. 15. In this cell coils were being dipped in lacquer which is cut with gasoline. A slight explosion occurred, and the contents of the cell immediately took fire. The two men who were in the cell got out quickly, one of them being much burned. The fire door was instantly shut, hose lines laid, and the fan at the top of the cell, which is kept constantly running to take away vapors, was stopped. The cause of the explosion is unknown. It probably came from a spark, possibly due to a match on the floor which evidently ignited gasoline vapor that was lying along the floor.
>
> The building in which the cells are located has an iron roof and is sprinkled. The fire in the cell was very fierce, and the large ventilator through the roof became hot enough to open two sprinklers, which were allowed to run at intervals so as to keep the iron roof and surroundings cool. After about two hours, the roof of the cell fell in. Water from two hose streams was poured into the cell, and the fire was immediately extinguished, having practically burned out everything combustible inside. The fire door, which was of the ordinary pattern, 2 ins. thick, stood during the fire. This is a most excellent test of a standard fire door, and shows it able to withstand a very severe fire.
>
> The cell is to be rebuilt on heavier lines, and a separate fan for each cell is to be provided. Loss, $734.48.

The plan of carrying on such dangerous work in isolated brick cells evidently has much to commend it, as shown by the fact that the fire, although burning for two hours, did not spread from the cell in which it started. The only ground for criticism appears to be that some portable chemical fire extinguisher was not at hand, or that holes were not provided in the cell walls through which such an extinguisher could be sprayed into the inside of the cell. It is for use in confined spaces and for fires fed by inflammable liquids that chemical extinguishers are of greatest use, and they should not be neglected by those responsible for the fire protection of manufacturing plants.

The railway statistics of the Interstate Commerce Commission for the year ending June 30, 1900, printed in another column, are of interest as representing conditions of prosperity such as have not been known in the railway world for a very long time. The gross earnings amounted to nearly a billion and a half, and the increase over the previous year was about 173½ million dollars. Of these increased earnings, 104½ million dollars went in increased operating expenses, made necessary largely by the heavy growth in traffic; and the stockholders received about 28½ millions of the balance in increased dividends. The total amount paid in salaries and wages during the year was 577¼ millions, while the holders of railway stocks and bonds received about 400 million dollars.

Not all the increase in earnings was due to increased traffic, for the figures show an increase in the average passenger mile rate from 1.925 cts. to 2.003 cts., and the freight rate per ton mile increased from 0.724 cts. to 0.729 cts. Small as these increases appear, they account for about $19,000,000 of the increased earnings of the railways.

People often speak of the average railway and base their ideas unconsciously on the railway lines with which they happen to be most familiar. Such ideas are often very erroneous. The man familiar with conditions on the trunk lines makes an estimate of one sort. The one who knows the ways of working on branch lines in thinly settled parts of the country has another and very different idea. The figures in this report, however, give the material from which a correct mental picture of the "average railway" of the United States can be formed. It is a line over which passes in the course of a year 735,366 tons of freight and 83,295 passengers. Now let us reduce these to terms of train service; for it is by counting the number of trains over a road that one usually estimates the traffic upon it. The average freight train load is 225 tons and the average number of passengers in a passenger train is 42. Dividing, we have 3,268 freight trains and 1,983 passenger trains. Making reasonable allowance for the Sundays and other days in the year on which traffic is more or less suspended, it may be concluded that the average United States railway moves about five freight trains and three passenger trains each way daily. This train service is performed, it may be noted, with an average equipment amounting to 20 locomotives, 18 passenger cars and 735 freight cars per 100 miles of road, and the total operating force in all departments for 100 miles of road amounts to 529 persons.

RECENT PRACTICE IN GRAIN ELEVATOR CONSTRUCTION.

The critical summary and comparison of American practice in fireproof grain elevator construction, by Mr. John Kennedy, Chief Engineer of the Harbor Commissioners of Montreal, which is published in another part of this issue, is a very concise and clear statement of a problem which deeply concerns elevator owners and grain shippers. As the result of his studies of the existing examples of fireproof grain elevators, Mr. Kennedy concludes in brief: First, that the preferable type of fireproof construction is that which imitates the familiar wooden elevator while avoiding its inflammability; second, that the best material for constructing incombustible elevator bins is steel; and, third, that the higher first cost of fireproof construction is more than compensated by the reduction in insurance charges.

That these conclusions are generally sound cannot, we think, be successfully disputed. The practical merit of the standard, suspended-bin elevator construction, which includes the storage space and operating machinery under one roof, has been amply demonstrated by long experience. Modern grain handling machinery has been designed and developed to meet the conditions existing in this type of structure, and taken altogether, it has reached a very perfect state of efficiency in the rapid and convenient handling of grain in the numerous transfers which grain undergoes in a modern elevator. So much cannot be said for the pneumatic and other special forms of apparatus required by other types of construction, whatever their inherent possibilities may be. In advising adherence to the standard wooden elevator structural arrangement, therefore, Mr. Kennedy has made a safe and practical recommendation, particularly since this standard construction lends itself as well as the use of steel and masonry as to the use of timber. With respect to the preferable material for incombustible bin construction, Mr. Kennedy's straightforward advocacy of steel seems to us to be eminently wise. Structurally no material has physical qualities better adapted to the requirements of a bin to hold grain than steel. It has the necessary tensile strength and capability to endure distortion in a high degree; it is economical in space consumed by the bin structure; it adapts itself to bins of different forms and sizes, and it involves no skill in workmanship not already commanded by structural and tank works of ordinary capacity in any locality. Neither concrete-steel construction nor steel-hooped tile construction possess in the same degree so many suitable qualities for the purpose. Some years ago when the proposition to use steel elevator bins was first made, fear was expressed in many quarters that they would cause injury to the grain from heating and sweating. Experience has shown these dangers to be negligible, if indeed they exist at all.

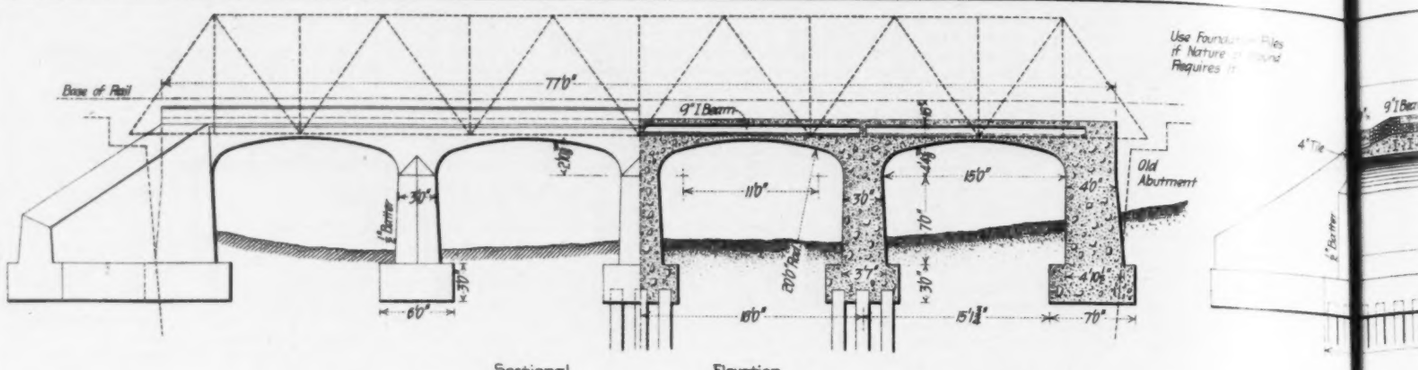


FIG. 1. CONCRETE BRIDGE OVER AMES CREEK.

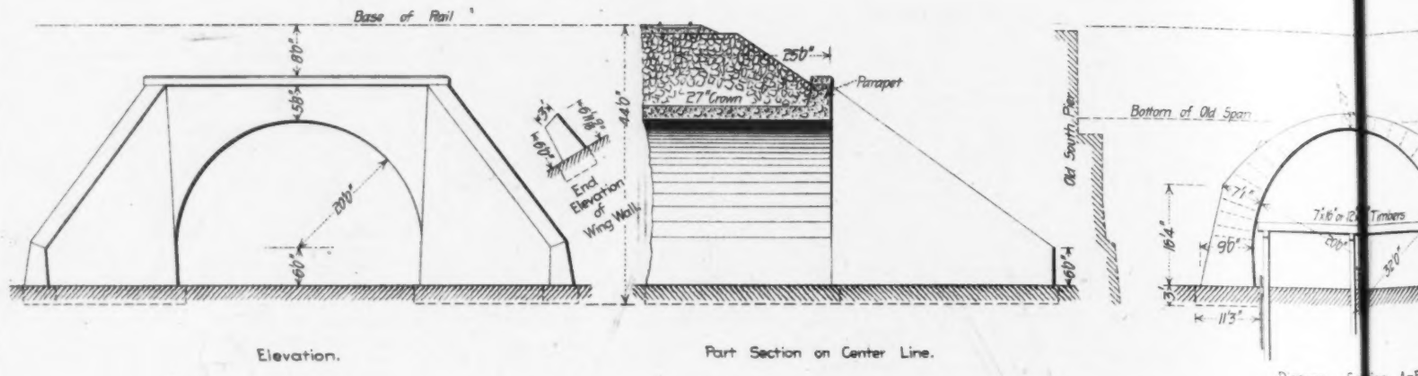


FIG. 2. 40-FT. CONCRETE ARCH BRIDGE NEAR SIGEL, ILL.

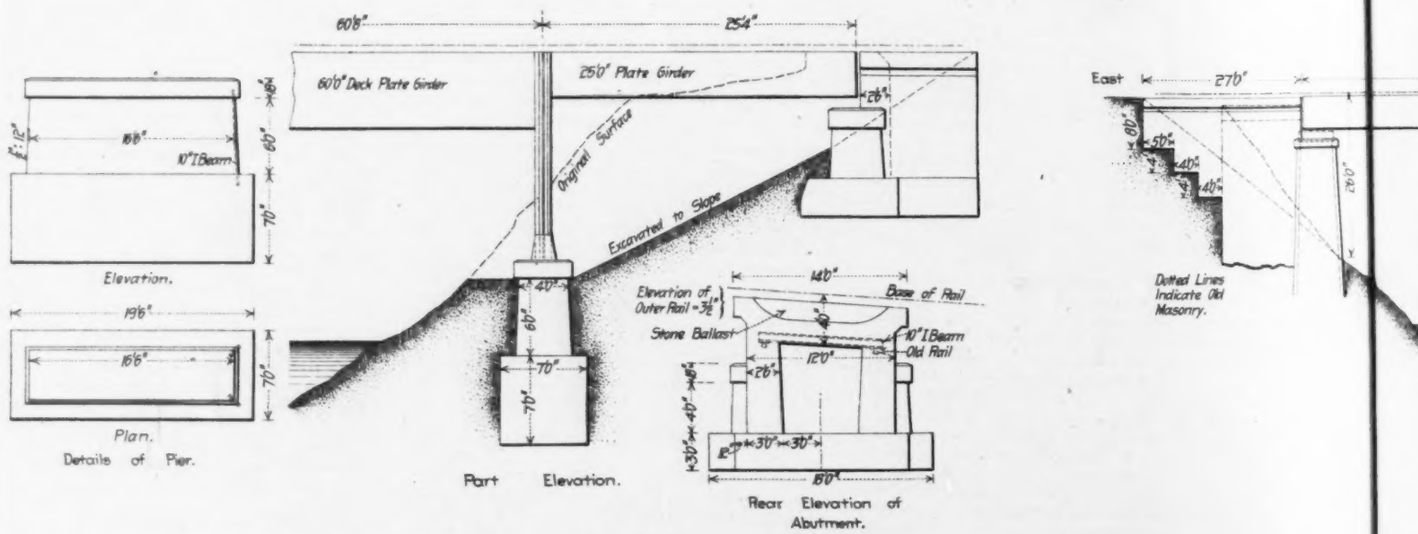
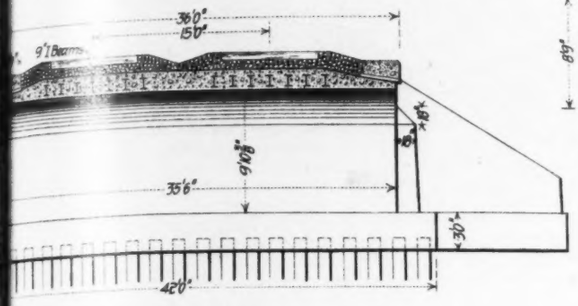


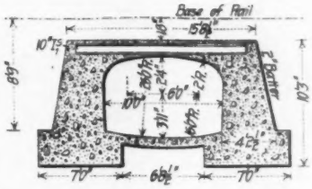
FIG. 10. PLATE GIRDER BRIDGE WITH CONCRETE PIERS AND ABUTMENTS.

CONCRETE BRIDGE AND CULVERT WO

H. W. Parkhurst, Engineer o



Cross Section.



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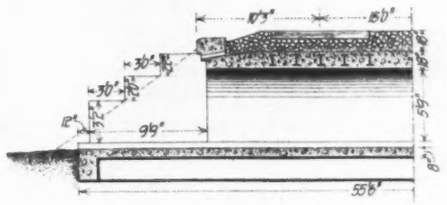


Half Longitudinal Section.

FIG. 6. STEEL CONCRETE CULVERT.

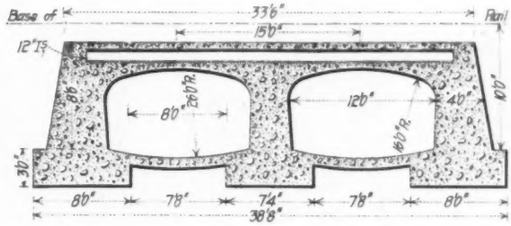
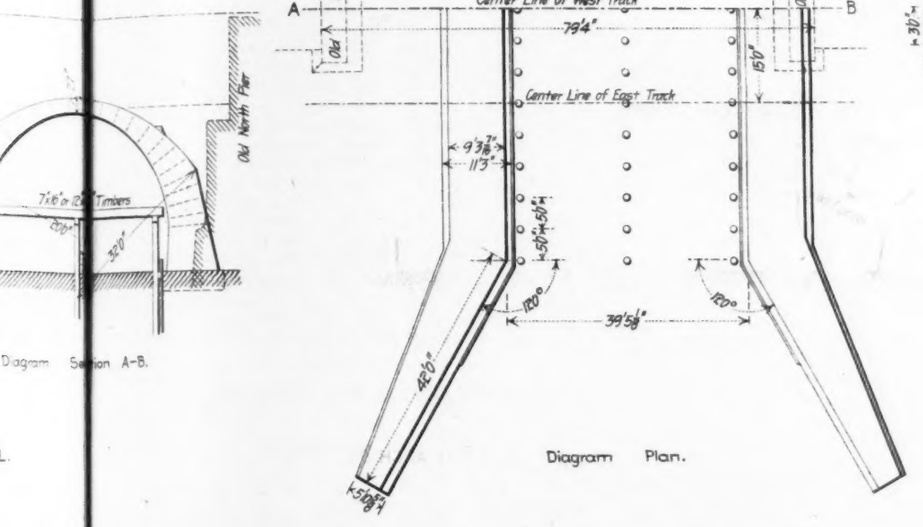


FIG. 8. DOUBLE-ARCH CULVERT.



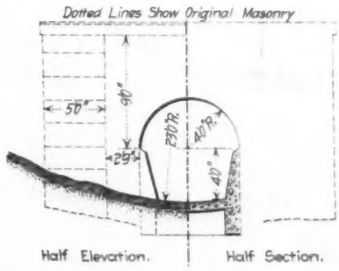
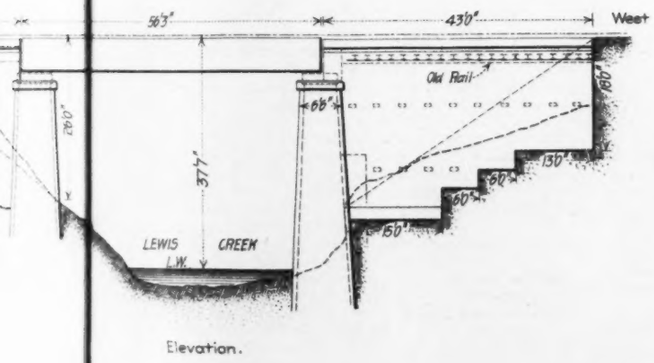
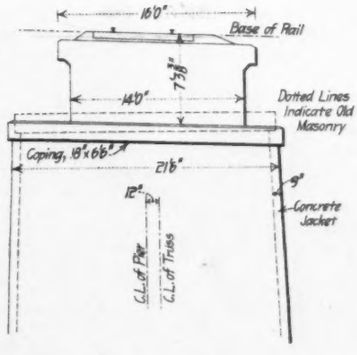


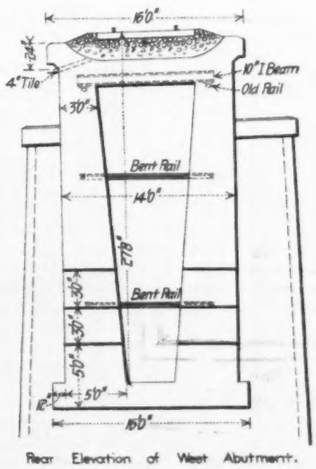
FIG. 9.
OLD MASONRY CULVERT WITH CONCRETE LINING.



Elevation.



Front Elevation of West Abutment.



Rear Elevation of West Abutment.

FIG. 11. BRIDGE-ABUTMENTS OF STEEL-CONCRETE CONSTRUCTION.

CULVERT WORK; ILLINOIS CENTRAL R. R.

urst, Engineer of Construction.

CHAS. HART, LITH., 90 VESEY ST., N. Y.

The most important of Mr. Kennedy's conclusions is by all odds the final one, that it pays the elevator owner and the grain shipper to undertake the extra first cost of the fireproof structure for the sake alone of the saving which they make in the insurance charges on their property. The nightmare of the elevator business has long been the fire risk. This risk has limited the size of the elevator which the owner could afford to build, and it has reduced the value of the stored grain as collateral for loans. In some of the great grain-growing states of the West, banks are prohibited by law from loaning money on uninsured grain in storage. Insurance rates are exceedingly high Mr. Kennedy, in his calculations, places them at the moderate figures of 2½ per cent. per annum on elevator property, and 0.25 per cent. for ten-day insurance on grain in storage. With fireproof construction, as Mr. Kennedy further points out the elevator owner can safely forego the protection of insurance on his property, and the shipper can secure his loans by insurance at rates which are but a fraction of those charged against grain stored in combustible wooden elevators. That these assumptions are not visionary is demonstrated by the fact that a rate of 50 cts. per $100 is made on grain stored in the new Great Northern Ry. steel elevator at West Superior, Wis., and by the more significant fact that the Minnesota State Legislature at its last session passed a law permitting banks to loan money upon uninsured grain stored in elevators which were certified as being fireproof by the State Railroad Commission.

It should be further pointed out that Mr. Kennedy's figures of the relative first cost of wooden and of fireproof elevators are probably based upon prices at Montreal, where timber is cheaper and steel construction is, if anything, more costly than in the United States, and that, therefore, the record of economy for the fireproof structure will be even greater in the United States than that shown in Mr. Kennedy's comparison. Finally, it will, we think, surprise those of our readers who have not followed the matter closely to find to what a considerable extent elevator owners are adopting fireproof construction, considering that barely five years ago its application to grain elevators was hardly more than an interesting speculation.

LETTERS TO THE EDITOR.

Draftsmen and Their Work.

Sir: Referring to the editorial note in your paper of July 11, I believe that the principal reason for so little distinction being made between different classes of draftsmen is that very few employers are themselves engineers or draftsmen.

The work of the draftsman (the professional draftsman) is seldom appreciated as it should be. A shop foreman may be able to "handle" men so as to increase output and may cut down their wages as far as possible, and may seem valuable to his employers for that reason; but the designer of machinery and structures can by carefully made designs save vast sums of money to his employers. Yet he often receives little or no credit therefor. How often must not a draftsman pose as inventor? How often must he not spend much time in wearying, brain-racking work without attaining any result? Often, when after much thought and painstaking work, he submits his design for approval, he finds it summarily rejected, and perhaps the employer does not hesitate to say that the draftsman is "slow."

Why are so few draftsmen married? Because a draftsman seldom has steady employment. "Skilled labor" is high-priced, and when business is not rushing the draftsman is "laid off," just like an ordinary mechanic. And so he goes from place to place designing power machinery, steel structures, tools, railroad material, and so on, in endless variety, and he must know everything, from harness-making to bricklaying.

A designing draftsman, a man who has spent years in college to acquire an education, who has worked in shops to get a practical experience, who constantly studies to increase his knowledge, and who takes interest in his work, is of great value to his employer. Yet often such a man gets only a trifle more compensation than the copyist draftsman.

It is not meant here to infer that a "college" education is essential to make a good designer. It is a well known fact that many of the most successful engineers have not had the advantage of a college education. The distinction should be made according to the quality of work done. There are very few good draftsmen, because a man who fulfills all the requirements of a first-class draftsman usually finds more remunerative employment. Not until engineers are more generally placed at the head of manufacturing concerns will there be any improvement in the condition of the draftsman. But then, again, when all engine works, all steel works, all tool works, all shipyards, etc., combine into one, there will be no competition and no inducements offered to the best men, but perhaps a limit fixed for salaries. Perhaps, then, after all, draftsmen and engineers will find it necessary to organize for self-protection, just like the trade unions.

July 15, 1901. M. M. S.

THE LIVERPOOL HEAVY TRAFFIC MOTOR-VEHICLE TRIALS.

The Liverpool Self-Propelled Traffic Association commenced its series of trials for self-propelled vehicles for heavy traffic on June 3, the last trials having taken place two years ago. This year two new classes were admitted, to test the merits of the present law limiting the maximum weight of such vehicles to 3 tons. A Class C car was admitted, capable of carrying a minimum load of 5 tons, at 5 miles per hour, and having a level platform area of not less than 95 sq. ft. In the Class D, the minimum load was 4 tons, with no requirements as to area of platform. As before, Class A was required to take a load of 1½ tons with a tare not exceeding 2 tons; the area of platform was 45 sq. ft.; the width of driving tire not less than 3 ins.; and the speed was to be 8 miles per hour. Class B cars were required to haul 5 tons on a tare of 3 tons; with a platform of 75 sq. ft., width of tires 5 ins., and speed of 5 miles per hour.

The vehicles entered for the trial were as follows:

Class A. Two; both by G. F. Milnes & Co.; London.

Class B. One; by Lancashire Steam Motor Co., of Leyland.

Class C. One; Thornycroft Steam Wagon Co., Chiswick.
Two; C. & A. Musker, Liverpool.

Class D. Thornycroft Steam Wagon Co., Chiswick.
T. Coulthard & Co., Preston.
Mann Patent Steam Cart & Wagon Co., Leeds.
Simpson & Bibby, Manchester.
Mechanical Transport Co.

The most severe tests of these vehicles in the first day's trial was the mounting of an incline varying from 1 in 22 to 1 in 9. The motors made these trials both light and fully loaded; the first being the severer test, as a less weight was available for adhesion. Though one or two of the vehicles almost "stalled," all finally succeeded in mounting the incline. On the return trip the cars were stopped by signal on the 1 in 9 grade, and the distance traveled after the signal was given was measured, as was the speed. All except the Mann vehicles had smooth tires; the Mann wheels had projecting rivet heads and grooves, and they slipped less than the others on the cobble-paving at the head of the incline.

The Mann vehicles were modified traction engines, straddled at the rear by a two-wheeled cart with a platform 12 × 6 ft. 4 ins., and 3 ft. 6-in. wheels with 5½-in. tires. Traveling speeds of 5 and 2½ miles per hour are provided for, at a working pressure of 150 lbs. to the sq. in. The boiler is of the locomotive type, fired at the side. There are two powerful brakes; one, a foot-lever strap brake; the other, a screw-brake acting on the rims of the cart wheels.

The Coulthard & Co.'s steam wagon was capable of developing 25 brake HP., and the engine is designed to run at 450 revolutions per minute. This engine is compound, with 3¾ and 7-in. cylinders and 6-in. stroke, with a working pressure of 225 lbs. per sq. in. The brake consists of two steel cables lined with hard wood blocks and coiled around the brake drum. The length over all is 18 ft. 5½ ins.; width over all, 6 ft. 6 ins.; height to top of stack, 8 ft. 8 ins.; platform, 12 ft. 6 ins. by 6 ft. 6 ins.

The C. & A. Musker wagons had left the shops so recently that there was no time to properly adjust them for the trials. This adjustment was especially necessary, as the working is almost entirely automatic. One wagon was designed for burning oil, and the other coke. In both the boiler is of the simple coil type, with the fire chamber entirely surrounded by the water tubing; the working pressure was 225 lbs. The engines, boiler, etc., are placed on a teak platform beneath the load platform, which latter was 18 × 6½ ft. in each case, on a wheel-base of 10 ft. × 5 ft. 7 ins. The platform is supported by springs, with no machinery attached to it; and the top of platform is 4 ft. above the ground light, and 3 ft. 9½ ins. loaded with 5 tons. The oil-fired car weighed 3 tons, 16 cwt., 2 gr.; and the coke-fired, 3 tons, 14 cwt., 3 gr. Both of these cars had to be withdrawn from the hill-climbing contest owing to lack of adjustment.

The Lancashire Steam Motor Co.'s wagon had a platform 12 ft. 9 ins. long by 6 ft. 5 ins. wide, and 3 ft. 6 ins. above the ground when loaded with 5 tons. The framing is channel steel. The wheels are of the artillery type; with front wheels 2 ft. 10 ins. diameter and 4 ins. wide, while the back wheels are 3 ft. diameter with 5-in. tires. The boiler is of the fire-tube type, and is placed at the front end of the platform; gas-coke is used as fuel, fired through a central chute. The working pressure is 225 lbs. per sq. in., but the safety valve is set at 210 lbs., the discharge passing into the water tank, which has a capacity of 150 gallons. The compound horizontal engine has 3½ and 6¼-in. cylinders, 6-in. stroke, and is designed to run at 420 revolutions per minute. High-pressure steam can be admitted to the low-pressure cylinder, when desired. All the working parts are in a dust-proof and oil-tight casing.

The two oil-fired cars entered by C. F. Milnes & Co. have a length of 17 ft. over all, and an extreme width of 4 ft. 9 ins. The platform rests on a steel channel frame, and can carry 3 tons. The motor is of the Daimler type, capable of giving 10 HP. at the brake. Change-gear on the constant system provides for four changes of speed. The circulating water passes through a cooler, and around the water-jacket cylinders. The cooling water passes around the tubes, and air is drawn through the tubes by a fan mounted on the crank-shaft of the engine. The cooling is said to be very efficient, the loss of water not exceeding one quart per day.

The Simpson & Bibby wagon weighed 3 tons, 19 cwt., 3 grs.; had a platform area of 7¾ sq. ft., and was designed to carry 5 tons, and at the same time haul a trailer with 3 tons up a 1 in 9 grade. The boilers were of the flash type, with indented tubes, with the pressure varying from 25 to 400 lbs., as the work demands. This variation of pressure is relied upon to vary the speed. The two engines each have three single-acting cylinders, with a total of 44 HP. The front wheels are 32 ins. diameter, with 4½-in. tires; and the drivers are 36 ins. diameter, with 6-in. tires.

The Thornycroft steam wagon is one of the company's standard patterns. It is designed to carry 4 tons of useful load, and under favorable conditions, haul a couple of tons on a trailer. It is 18 ft. 6 ins. long by 6 ft. 6 ins. wide, and 9 ft. high. The wheel-base is 10 × 5½ ft.; the platform is 12 ft. 6 ins. by 5 ft. 8 ins. The Class C Thornycroft is claimed to be the largest car yet submitted. It is 22½ ft. long by 6½ ft. wide, and 9 ft. 10 ins. in extreme height. The wheel-base is 12 ft. 6 ins. by 5 ft. 7 ins.; and the makers claim that this car will easily take 7 tons of paying load on its platform. The boiler is of the Thornycroft straight water-tube type, fired with coke from the top, through a central chute. The engine is of the compound horizontal type, with 4 and 7-in. cylinders and 5-in. stroke; at 800 revolutions per minute, taking steam at 200 lbs. per sq. in., the engine generates 35 I. HP. The car entered by the Mechanical Transport Co. was not completed in time and took no part in the trials.

London "Engineering," to which we are indebted for these notes, says that there was little opportunity for testing the respective merits of oil and coke fuel, as only two of the first type engaged in the trials, and these were in Class A, where there were no steam cars. On the level the oil-fired cars ran more rapidly than most of the steam cars; but in up-hill work the steam cars had the advantage, maintaining their speed better.

In regard to the use of heavier motor vehicles, it is pointed out that in Liverpool the "lorries" used along the docks weigh about 2 tons each, and three horses sometimes draw as much as 10 tons

upon them, and the average load is about 7 tons. As the horses are hitched tandem, the whole turnout is from 50 to 60 ft. long; while the big Thornycroft car for a 7-ton load is only 22 ft. 6 ins. long. But it is also a fact that while the car is being loaded or unloaded it is idle for several hours; and this delay is a dead loss in the case of the motor, and is necessary as rest in the case of the horse. These unavoidable intervals of rest tend to considerably diminish the range at which the motor car can compete with combined railway and horse traction. At present, however, the greatest drawback in the use of motor wagons is the legal limit of tare. With a horse-drawn 2-ton lurry hauling 7 tons, the motor constructed on the same lines would have to bring the weight of boiler, engines and accessories under 1 ton, if the legal tare of 3 tons is not to be exceeded. No cars so far entered comply with these conditions; though the Leyland firm had a car capable of taking 5 tons, and within the 3-ton limit of weight for the vehicle.

The final report of the judges has not yet been published; but it is understod that a gold medal has been awarded for the two oil-fired cars entered by G. F. Milnes & Co.; and a similar award has been made to the Lancashire Steam Motor Co., for their car in Class B, and to the Thornycroft Steam Wagon Co. for the car entered in Class C. Awards for the vehicles in Class D are still under consideration.

A SUBMARINE BOAT DESTROYING DEVICE is being experimented with in England. It consists of a spar torpedo carried on a boom 40 to 50 ft. long, supported by a crutch in such a way that it may be swung out into the water. It is expected that the concussion from the explosion of the torpedo will be sufficient to disable a submarine boat within the radius of 60 to 100 ft., while the destroyer carrying the boom, being only partly immersed, will be uninjured.

THE TURBINE STEAMER "KING EDWARD," lately built as a Clyde passenger steamer, made 20.48 knots on its recent trial trip. This steamer—the first commercial test of the Parson's steam-turbine machinery, is 250 ft. long, 30 ft. beam, 10 ft. 6 ins. molded depth to the main deck. She was built by Wm. Denny & Bros., of Dumbarton. She contains three Parson's steam turbines working compound, side by side. Steam admitted to the high-pressure turbine,expands five-fold and is then passed to the two low-pressure turbines; where it expands 25-fold and then goes to the condensers. Each turbine has its own shafting; with a single screw on the center shaft and two propellers on each of the side shafts. Special turbines inside the exhaust ends of the low-pressure turbines are used for going astern with the side screws. In the trial the mean revolutions were 740 per minute; steam at the boilers was 150 lbs. to the sq. in.; the vacuum was 26½ ins.; the air-pressure in the stokehole was equal to 1 in. of water. The estimated power was 3,500 I. HP., as no indicator diagrams could be taken. The weight of the steam and propelling machinery, shafting, steam pipes, condensers and water in them, etc., was only 66 tons, or about half the weight of ordinary machinery developing equal horsepower. The engines ran noiselessly, and there was very slight vibration,right astern, due to the propellers.

FIREPROOF GRAIN ELEVATORS IN AMERICA.*

By John Kennedy,† M. Am. Soc. C. E.

The grain elevators examined were in the cities of Duluth, Minneapolis, Chicago, Cleveland and Buffalo, and they comprised examples of all the chief types of elevators of wholly fireproof materials which are known to have been built, or are being built on this continent.

For convenience of description and consideration the elevators examined may be divided, as regards bin construction, into four types:

(1) Those having rectangular grain bins built of steel plates; (2) those having cylindrical bins, commonly called tank bins, built of steel plates; (3) those having cylindrical bins built of tiles strengthened with steel hoops; and (4) those having cylindrical bins built of concrete strengthened with steel hoops.

Of the first type, or those having rectangular steel bins, a notable example is the Great Northern elevator at Duluth (West Superior, Wis.—Ed.). It is of 3,000,000 bushels capacity, and is the largest and amongst the first of its kind. The bins are 14 ft. 9 ins. square by 85 ft. high, holding 14,500 bushels, except a few which are of two-thirds, half or quarter capacity. The bins are arranged in straight rows lengthwise and crosswise, and they are formed of steel plates of such lengths as to reach from corner to corner, the corner junctions being formed with four angle bars and rivet fastenings. The plates are stiffened by angle bars riveted to each side and by flat tie-bars reaching across the bins, placed edge up. For the smaller bins, the space of two standard bins is divided into three, one is divided into two, or one into four. The bins have steel plate hopper bottoms at suitable height to allow cars to pass beneath, and they are carried on steel columns reaching through the ground floor to foundation piers beneath. The floor which covers the heads of the bins and the next above it are, for some unexplained reason, of wood plank on steel joists, but all other floors are of steel or other fireproof materials. There is no framing or walls surrounding the bins, but they are protected from the sun and weather by corrugated iron sheeting attached to them in such way as to give a 6-in. air space all round between the sheeting and the outside plates of the bins. The framing of the building above the bins is of steel covered with iron sheeting and fireproof roofing. The elevator legs and heads, the garners, weighing hoppers and spouting are all of steel. With the exception of the two wooden floors, the wooden casings and frames of the cleaning machines, the elevator belts, driving ropes, and a few small wooden sills for machinery, everything worth noting, of both building and machinery, is of non-combustible material.

The elevator is fitted for receiving from cars and delivering into large boats. For receiving it has two tracks extending through the building lengthwise and holding nine cars each, and for delivering it has telescope spouts supported by cranes and convenient tackle. The machinery is all of the most improved description and largest capacity, and is driven by electricity.

The construction of the elevator was commenced about two years ago, but owing to delays in obtaining steel and difficulties incident to a novel character of construction, it is hardly yet completed. About a fourth of the bins and machinery have been in use, and are found to work well, and the remainder are very nearly ready for use.

At Minneapolis there are also examples of elevators having square steel bins, in which the square bins are essentially the same as those in the Great Northern elevator of Duluth, but the Minneapolis elevators as a whole differ from the Great Northern in having only part of their storage capacity in square bins and the remainder in round bins. In the Pioneer steel elevator of Minneapolis, for instance, finished about a year ago, and of about 1,200,000 bushels capacity, there is a central working-house which contains the receiving and delivering machinery, which is fitted with square steel bins, but they are of only 200,000 bushels aggregate capacity, and the main storage capacity of the elevator is in ten circular steel bins of 100,000 bushels each, arranged in two annexes of five bins each. The square bins of the Pioneer are built and supported in substantially the same way as those of the Great Northern, but their outer sides stand open to the weather, without walls or sheeting of any kind. In the working-house containing the square bins, the ground floor is of concrete, and the upper house floors, frames and sidings are of steel. Everything about the whole elevator and annex bins is of non-combustible material except the belts and cleaning machines.

Another Minneapolis elevator, of 1,800,000 bushels capacity, under construction, is to be of practically the same construction as the Pioneer, except that the tank annex is to be all at one end and everything but the belts will be non-combustible. Even the cleaning machinery will have steel casings and frames. The elevator is notable as being mainly owned by its builders, who are known as elevator builders of great skill and experience, and who may be considered as building that which their skill dictates as best suited the requirements of the place, and most likely to be profitable as a venture.

Of the second type of steel elevators, or those having circular bins of steel plates; amongst the early examples are the electric elevator at Buffalo, and the Canadian Pacific Railway elevator at Fort William, Ont. Later examples are the Great Northern of Buffalo, and the storage annex of the Pioneer steel elevator at Minneapolis; and the latest are the American Linseed Co.'s and the Buffalo Elevating Co.'s elevators under construction in Buffalo, and the annex of another under construction in Minneapolis. In all of these, except the Great Northen and the Buffalo Elevating Co.'s elevator under construction in Buffalo, the bins are simple cylindrical tanks built of steel plates and placed in rows with their bottoms at ground level. The grain is taken in from grain boats or cars by machinery placed in a house at the end of the rows or groups of bins, and is sent to the bins by overhead conveyors which carry and drop it into any desired one. Beneath each row of bins is also a conveyor by which the grain is carried from any bin back to the working-house where it is elevated and shipped or re-stored, as may be desired. The bins are roofed overhead, but the sides are not covered. In the Buffalo examples, the bins are of various sizes, but in those at Minneapolis they are all of about 50 ft. diameter, and 100,000 bushels capacity each.

In the Great Northern elevator of Buffalo, the circular bin system is quite differently treated. In it the bins are all supported on steel columns with their hopper bottoms at about the usual spouting height above the ground floor, and the elevator legs and working machinery, instead of being all at one end, is distributed throughout the house and the grain is spouted from the bins to the boots, and from the heads to the bins as in ordinary elevators. There are thirty circular bins of about 39½ ft. diameter, and 75,000 bushels capacity each, and in their interspaces are twenty-seven circular bins of about 15½ ft. diameter and 12,000 bushels capacity. A number of the irregular-shaped interspaces formed between the small and large cylinders have been further utilized by connecting the cylinders by steel plates, thus making little bins of about 2,000 bushels capacity. The bins are housed around by steel framing and sheeting and are surmounted by the usual upper stories and cupola for containing the elevator heads, spouting, weighing hoppers, etc. The elevator has a storage capacity of about 2,000,000 bushels, and is fitted for receiving from boats and for delivering to cars on tracks outside the house.

In the elevator of the Buffalo Elevating Co. (practically the Lehigh Valley Railroad Co.) the round steel bin system is being skilfully used in still another way. It is yet in the early stages of construction, but it is intended to be a working and storage-house for receiving from lake boats and delivering into canal boats and cars. The circular bins are supported on steel columns, with their bottoms at spouting height above the ground floor. They are 15½ ft. diameter by about 70 ft. high, and placed a foot apart, which gives circular bins of about 10,500 bushels capacity and interspaces of about 5,000 bushels capacity, which are utilized as bins.

The third type of fireproof construction, or that in which the bins are of tiles has thus far been used only for storage annexes, and the only examples seen are two in Minneapolis. In these the bins are circular, of 50 ft. diameter and 100,000 bushels capacity each. Their bottoms are at ground level, on concrete foundations, and they are filled and emptied by conveyors overhead and underneath. The walls of the bins are of specially-molded glazed hollow tiles laid in two thicknesses, with steel hoops built in to resist the internal pressure of the grain. Only the inside of the bins is used for storage; the interspaces are not utilized.

Of the fourth, or concrete type, there is only one example, and that is an unfinished elevator at Duluth. The bins proper are being built of circular form, and in rows at about 4 ft. clear distance apart, with connecting walls to separate the interspaces. The bins are 50 ft. diameter and 100,000 bushels capacity, and the interspaces, which are also intended to be utilized, are of about 30,000 bushels capacity each. The walls of the bins are of high-class concrete, 12 ins. thick at the lower part and about 9 ins. at the top, and they

*Report made to the Harbor Commissioners of Montreal, Canada.

†Chief Engineer, Harbor Commissioners of Montreal, Montreal, Canada.

are strengthened by steel hoops and diagonal wire lacing, built in. The bins are being roofed over, but they are to have no housing around them.

It is obvious, on considering the main characteristics of the elevators described, that the new materials which have been adopted in order to make them fireproof have in great measure governed the larger features of the elevators as well as the details of construction. When wood alone was used the rectangular plank bin was so clearly the best that no other was used, and the limitations of the material and mode of construction practically limited the general arrangement to groups of rectangular bins of 15,000 bushels or less capacity each. Bins of such material and size have the advantage of suitability for the storage of grain of all sorts and conditions, and lots of all usual sizes; but being of inflammable material, the risk of fire made it prudent to keep the aggregate capacity of the group, or single elevator building, to something like a million bushels. On the other hand, steel, the first and most generally adopted material for wholly fireproof elevators, is best suited to the construction of bins of large size, of say 100,000 bushels capacity and of circular shape, and being fireproof they may be safely grouped to give any required aggregate capacity. In early examples of steel elevators the bins were, therefore, made circular, chiefly of large capacities, and with bottoms at ground level, but this arrangement is unsuited to the storage of grain in small lots, and it involves the use of grain-handling machinery of very limited capacity, and gives limited freedom in changing heated grain from bin to bin. Its main advantages are economy of construction and freedom from fire risk. An improvement in the circular bin system which eliminates some of its most serious defects was that adopted in the Great Northern at Buffalo, by raising the bottoms of the bins to spouting height above ground, putting small round bins in the spaces between the large, and making bins of the remaining interspaces, and by suitably increased working machinery of ordinary type. A still further and, for most conditions, the best development of the circular bin system is that on the Buffalo Elevating Co.'s elevator, in which the bins are only about 11,000 bushels capacity each, with utilized interspaces of about half the capacity, and all at high level so as to be served by ordinary working machinery. While the circular bin system was being thus developed a more radical departure was made in the use of steel by discarding the circular bin altogether and reverting to square bins of moderate size, placed at high level and served by ordinary machinery enclosed by steel housing; or, in other words, in using steel in such way as to make the enlarged and improved copy of the best features of wooden elevators, while avoiding their inflammability. A compromise type suited to certain requirements, and of moderate cost, is that of the Pioneer elevator in Minneapolis, in which there is a working-house with square steel bins of convenient size and an annex of large circular steel bins to make up the total required storage capacity.

The tile and concrete systems are obviously the outcome of efforts to obtain suitable materials other than steel plates, for the construction of incombustible bins. Thus far the bins under both systems have been only of large size and circular form, and seated at ground level, and they have, therefore, the same limitations as to use as have steel bins of the same size and form.

As regards the action of the various fireproof materials upon the grain in contact with them, and the sufficiency of the materials to bear the strains of service, experience is short, but so far as it goes indicates that none of them do any harm whatever to the grain, nor are they harmed by grain in any condition. It was at one time feared that steel bins might sweat or heat the grain, but nothing of the kind has taken place. For the resisting of load strains steel bins can, of course, be made of any required strength, and tile bins as built and used have proved to be of ample strength. Some of the newly-built concrete bins at Duluth failed on a test made by filling an interspace with grain, but the failure has not deterred the owners and builders from continuing the building of the other bins required to make up the full intended number.

In applying the information thus set forth to the case of the proposed Montreal Harbor elevators, the following are the main questions which arise and the ways in which, in my judgment, they should be met. The questions are for convenience, worked out for one elevator of a million bushels capacity, but the reasoning is applicable to other capacities and more elevators.

(1) As to whether the elevator building be built of wood or of fireproof materials. The question obviously touches both the owner and the user, and its solutions as regards both may be made on the following assumptions:

A million-bushel wooden elevator will cost, without wharf conveyors, say $300,000, and its insurance rate may be taken at about 2½%. One of fireproof materials will cost about $400,000, and on it there need be no insurance. The interest on first cost will be, say 3½% per annum, and alike for both kinds of elevators. An elevator, like all other plant used in trade, will soon become obsolete because of changing conditions, and must be practically rebuilt or replaced long before worn out. A renewal fund should, therefore, be set aside which, at say 3½% yearly compound interest, will provide for total renewal in say 25 years. Such renewal fund will be equal to 2.9% per annum on the first cost. Maintenance and working expenses will about balance in the two kinds of buildings and need not be taken into account. The average storage term of grain taken into the elevator for storage during navigation season, apart from that merely transshipped, may be taken at ten days; and the grain insurance rate for that term in a wooden elevator may be taken at 0.25%. Probably no insurance need be carried on grain in a fireproof elevator, but in case it should be required by banks making advances it would be about 0.05%. For winter storage the term may be assumed at two months, for which the insurance rate would be about 0.75% in a wooden elevator, and 0.15% if demanded in a fireproof one. The owner's yearly investment and insurance expenses will then be:

For a wooden elevator: Interest, 3½%; renewal fund, 2.9%; insurance, 2½%; total 8.9% on $300,000; first cost, per annum	$26,700
For a fireproof elevator: Interest, 3½%; renewal fund, 2.9%; (insurance, none); total 6.4% on $400,000, first cost	25,600
Difference per annum to owner in favor of fireproof elevator.	$1,100

The grain shippers' insurance charges will be:

With a wooden elevator:	
For summer 10-day insurance	0.25%
For winter 60-day insurance	0.75%
With a fireproof elevator:	
For summer 10-day insurance	0.05%
For winter 60-day insurance	0.15%

The results of the estimates would, of course, be changed by change in the assumed data, but it is clear that a fireproof elevator could cost the commissioners no more per annum than would a wooden one, and that it would save to the shippers who store in it about four-fifths of their storage insurance. This conclusion is confirmed by the fact that almost all elevators built within the past two years are of fireproof materials. I would, therefore, recommend that any elevator built by the commissioners for general use be made fireproof.

(2) The chief requirements to which an elevator for the central part of the harbor should comply as regards its machinery and storage arrangements.

It must, of course, be placed and equipped so as to take in grain from canal boats and cars, and to deliver to, say, four ships at any of ten berths, and also deliver to harbor lighters; and it should perform any or all operations separately or together. Grain shipments through Montreal are usually made up of small lots whose identity must be preserved, and the elevator bins should therefore be of small size, say about 12,000 bushels capacity each. These conditions would, on the whole, be best fulfilled by an elevator resembling the Great Northern of Duluth in its main features, but greatly reduced in size, and modified in structural details.

(3) The materials of which the bins should be built.

For the fulfillment of the foregoing requirements steel would be altogether the most suitable and economical material.

CONCRETE-STEEL BRIDGE AND CULVERT CONSTRUCTION ON THE ILLINOIS CENTRAL R. R.

(With two-page plate.)

In connection with the work of double tracking and the extensive permanent improvements which are now being carried out on the Illinois Central R. R., a large number of culverts, old iron bridges and timber trestles are being replaced by concrete structures or by new steel structures on concrete abutments and piers. In most of these cases, the concrete is reinforced by steel beams or rails embedded in the concrete. Many old piers and abutments of stone masonry, built with poor cement or poor stone, are being encased or jacketed with concrete to preserve them, and many culverts of a similar character of masonry are being lined with concrete for the same purpose. When the structures occur on curves, the superelevation is given in the concrete masonry, this being done for curves as light as 4° and 5°, and for speeds as low as ten miles per hour. During 1900, the cost of concrete structures built was about $140,000. The accompanying illustrations represent a variety of classes of concrete and steel-concrete structures, for plans and particulars of which we are indebted to Mr. H. W. Parkhurst, M. Am. Soc. C. E., Engineer of Construction of the Illinois Central R. R.

In Fig. 1 is shown a concrete bridge 77 ft. long, consisting of four arch spans. This is a double-track structure, replacing a light 82-ft., single-track iron bridge over Ames Creek, near Buckley, Ill. The width over the copings is 36 ft., the tracks being spaced 15 ft. c. to c. The spans are 15 ft in the clear, with a radius of 20 ft. for the crown and 2 ft. for the haunches. The concrete is 18 ins. thick at the crown, and over each arch are laid 9-in. I-beams, 17 ft. 6 ins. long. There are seven of these beams under each track, spaced 18 ins. c. to c., and so placed that at the center of the arch there are 3 ins. of concrete below and 6 ins. above the beams. Concrete made of small material is used for the bottom 3 ins., and for 1½ ins. above the beams. In cross-section, the top of the concrete is flat, but slopes at each side to the coping or low parapet, through which 4-in. drain tiles are laid at intervals. On the concrete is laid the stone ballast 18 ins. thick, in which the ties are embedded, as shown. The piers are 3 ft. thick at the springing line, and the abutments 4 ft. thick at the same level. The east side of the bridge was first built, parallel with the old structure. When this was completed, traffic was diverted to it, the old bridge was removed, and the west half of the concrete structure built. This bridge contains about 725 cu. yds. of concrete. The four arches give ample waterway, and the cost of the double-track concrete structure was less than that of a single-track steel structure of modern design and weight.

One of the larger concrete structures, and one in which no steel beams are used, is the 40-ft. arch over Green Creek, near Effingham, Ill., which is shown in Fig. 2. This replaces an old iron deck span. The arch has a radius of 20 ft. on the intrados and 32 ft. on the extrados. The height from top of foundation to lower side of crown is 26 ft. The thickness of the crown is 27 ins., and at each end is a parapet wall to support the bank, the rail level being 12 ft. 9 ins. above the crown. The walls are 7 ft. 1 in. thick at the haunches, and 9 ft. thick at the springing, while the footings are 11 ft. 3 ins. wide. The dotted lines on the section represent the way in which the concrete was laid, in radial courses instead of horizontal courses. The railway company put in the piles and caps to support the centering, which was built by the contractors. This centering was left in place until the filling of the bank had been completed. The foundation sheeting was left in place, being cut off level with the ground. A view of the bridge, with the centering in place, is shown in Fig. 3. A central tower on each side served to carry the staging for the workmen and as a support for the ends of braces to support the forms for the wing walls. The concrete was mixed by a Drake machine and deposited in place by wheelbarrows. This bridge was built in connection with double tracking. The original deck single-track span was raised about 1 ft., to clear the crown of the new arch. The arch was entirely completed, and seats were built for falsework bents under the old span, which was then removed, the single track being carried on bents until the bank filling

For arch rings of arch culverts and for parapet headwalls and copings to same, Portland cement concrete, in proportions of 1, 2 and 5, shall generally be used. Concrete of these proportions shall also generally be used for parapet walls behind bridge seats of piers or abutments, and for the finished copings (if used) on wing-walls of concrete abutments, also for arch work in combination with I-beams or in combination with iron work for transverse loading.

Bridge seats of piers and abutments and copings of concrete masonry which are to carry pedestals for girders or longer spans of iron work, shall generally be made of crushed granite and Portland cement, in the proportion (by measure) of 1 part of approved cement, 2 parts of fine granite screenings, and 3 parts of coarser granite screenings, the larger of which shall not exceed ¾-in. in greatest dimension.

MIXING CONCRETE.

All concrete must be mixed on substantial platforms of plank or boards securely fastened together, so that the various materials of the concrete can be kept entirely free from admixture of foreign matter. Hand-mixed concrete shall not be made in batches of more than one yard in each batch. The proper amount of the several kinds of material shall be measured in some way which is entirely satisfactory to the engineer or inspector in charge of the work, so that they may be satisfied that the requisite proportions of each kind of material are delivered for each batch of concrete. Satisfactory methods of measurement will be the use of headless and bottomless barrels for measuring sand and broken stone; the use of boxes into which the sand and stone may be cast and leveled off (the boxes then being removed), or the use of square and uniform sized wheelbarrows, expressly designed for this purpose. The measurement of sand and broken stone in the ordinary shallow, round bottom wheelbarrow will not be considered satisfactory, and shall not be permitted.

The detail of mixing concrete by hand shall be generally as follows: the proper amount of sand shall be measured out and spread upon the concrete platform, and the proper amount of cement shall be delivered and spread upon the same; the sand and cement shall be turned over dry, either by means of shovels or hoes, until they are evenly mixed. They shall then be wet and made into a rather thin mortar, and shall then again be spread into a uniform and thin layer upon the concrete platform. The proper amount of concrete stone (the same having been previously drenched with water) shall be spread upon the mortar, and the whole shall be turned over at least twice, either by shovels or hoes, before it is loaded into wheelbarrows, or in any other way taken to be placed in the work. In wetting the mixture of sand and cement to make the mortar, and in wetting the subsequent mixture of stone, sand and cement (if necessary), a spray or sprinkler shall be used. The water must not be dashed upon the mass in buckets or large quantities, or by means of a jet. The inspector shall insist that the resultant mixture of sand, cement and stone is as nearly as possible uniform in character, the mortar being equally distributed throughout the mass of the stone. The inspector shall also see that the mixture is neither too wet nor too dry. It should be of such a consistency that, when thoroughly rammed, it will quake slightly, but it should not be thin enough to quake in the barrow, or before ramming. The inspector shall satisfy himself that the proper proportions of cement, sand and stone are used, checking from day to day or from time to time with the total amount of each which is received and used.

Machine-mixed concrete shall be made of the same general consistency as the hand-mixed concrete above specified. Proper precautions shall be taken to see that the requisite proportions of the different ingredients are used. If machines are used which are not provided with devices to deliver each of them, the process of making the concrete shall generally be as follows: The proper amount of sand, cement and stone for a batch not to exceed one yard of concrete shall be delivered on the platform, and roughly mixed together so that when the dry mass is cut down and delivered to the mixer by means of shovels, proper amounts of each of the ingredients are handled in each shovelful.

It will not be regarded as a satisfactory process to deliver crushed stone, sand and cement at random to the mixer, without taking some special means, as above described, to insure the delivery of the proper quantities of each ingredient as nearly as may be simultaneously.

MOLDS.

Molds of substantial character shall be made in which to construct all concrete work. The material for these molds shall be furnished by the contractor, and the expense of furnishing this material and of constructing and removing all molds shall be covered in the price per yard paid to the contractor for the several classes of concrete work called for. The face of the mold next to the concrete shall be finished smooth, planks which are dressed at least on one side being employed for this purpose. Material for the molds shall be of sufficient thickness, and the frame holding them shall be of sufficient strength, so that they shall be practically unyielding during the process of filling, tamping, etc. The different parts of the frame work for the mold may be fastened together, if desired, by tie rods or wires extending through the concrete. If tie rods are used they shall be so designed that no iron work will be left outside of the concrete or within less than 2 ins. from the face of the same when the molds are removed. This may be accomplished by sleeve nut connections which will permit the removal of the projecting ends of bolts or rods, etc., leaving only small holes in the concrete which can be stopped with pointing mortar after removing the molds. Another satisfactory method of bracing molds is to construct them with cross ties between the front and back, these ties to be placed at frequent intervals above the lower portion of the mold and to be removed as the concrete is built up, the studding out of which the molds are constructed being sufficiently long to extend above the top of the finished masonry, and at least one set of ties being used above this level. In general 2-in. plank, sized to approximately 1¾-in. thickness, shall be used for the facing of all molds, and studding for frames shall be placed at intervals not more than 4 ft. apart. The planking forming the lining of the molds shall invariably be fastened to the studding in perfectly horizontal lines, the ends of these planks shall be neatly butted against each other, and the inner surface of the mold shall be as nearly as possible perfectly smooth, without crevices or offsets between the sides or ends of adjacent planks. Where planks are used a second time, they shall be thoroughly cleaned, and, if necessary, the sides and ends shall be freshly jointed so as to make a perfectly smooth finish to the concrete.

The molds for projecting copings, bridge seats, parapet walls, and all finished work shall be constructed in a first-class, workmanlike manner, and shall be thoroughly braced and tied together, dressed surfaces only being exposed to the contact of concrete, and these surfaces shall be soaped or oiled if necessary, so as to make a smoothly finished piece of work. The top surfaces of all bridge seats, parapets, etc., shall be made perfectly level, unless otherwise provided in the plans, and shall be finished with long, straight edges, and all beveled surfaces or washes shall be constructed in a true and uniform manner. Special care shall be taken in the construction of the vertical angles of the masonry, and where I-beams or other iron work are not used in the same, small wooden strips shall be set in the corners of the mold, so as to cut off the corners at an ogle of 45°, leaving a beveled face about 1½ to 2 ins. wide, instead of a right-angled corner.

Where wing walls are called for which have slopes corresponding to the angle of repose of earth embankments, these slopes shall be finished in straight lines and surfaces, the mold for such wing walls and slopes being constructed with its top at the proper slope, so that the concrete work on the slope may be finished in short sections, say from 3 to 4 ft. in length, and bonded into the concrete of the horizontal sections before the same shall be set, each short section of sloped surface being grooved with a cross line separating it from adjacent sections. It will not be permitted to finish the top surface of such sloped wing walls by plastering fresh concrete upon the top of concrete which has already set, but the finished work must be made each day as the horizontal layers are carried up, to accomplish which the mold must be constructed complete at the outset; or, if the wing wall is very high, short sections of the mold, including the form for the slopes, must be completed as the horizontal planking is put in place.

Foundation concrete may be put into excavations without the use of molds, provided the sides of the excavation are reasonably true and the material is sufficiently firm, so that the concrete may be rammed thoroughly without yielding to the adjacent earth. Where a cheaper kind of concrete is used for foundation work, the top of the same shall be finished smooth and level, the corners and edges being thoroughly rammed and compacted, and the whole surface filled full of mortar. It will not be satisfactory to leave a honey-combed surface or one on which a lot of loose concrete stone is left scattered about.

It is not expected that the surface of such foundation work shall be accurately leveled unless cut-stone masonry is to be built upon it, but the inspector must insist that that portion of such foundation concrete which projects outside of the masonry which is to be built upon the foundation must be thoroughly rammed and compacted, and must have a finished surface. If this cannot be accomplished without constructing a mold for the upper portion of such foundation, the contractor shall furnish material and construct such mold, and the cost of the same shall be included in the price of the foundation concrete.

Iron rails to be furnished by the railroad company shall be laid and imbedded in such manner as may be specified in such foundation concrete as in the opinion of the engineer of bridges needs such strengthening, and no extra charge, except the actual cost of handling the same, shall be made by the contractor for such work, but the volume of such iron shall be estimated as concrete.

Where I-beams are to be placed in the angles of concrete piers as a protection against ice, drift, etc., these shall be set up and securely held in position so that they will extend 1 ft. or more into the foundation concrete. The planking of molds shall be fitted carefully to the projecting angles of these I-beams and small fillets of wood shall be fitted in between the inner faces of the mold and the rounded edges of the I-beam flanges so that no sharp projecting angle of concrete will be formed as the work is constructed.

FIG. 3. 40-FT. CONCRETE ARCH BRIDGE; ILLINOIS CENTRAL R. R.

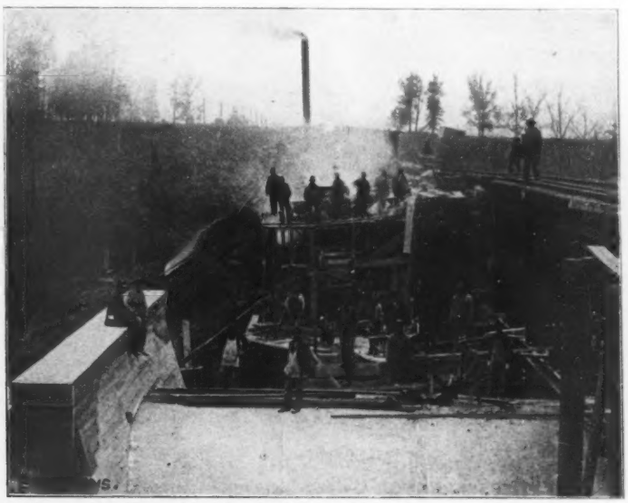


FIG. 4. CONSTRUCTION OF 40-FT. CONCRETE ARCH BRIDGE.

was finished. The arch is 65 ft. long, and has wing walls 42 ft. long, making an angle of 120° with the arch.

The footings are of natural cement concrete; 1 to 2 to 5. The wing walls and the arch to the level of the haunches are of Portland cement concrete, 1 to 2½ to 6. The arch above the haunches, and the parapet coping, are also of Portland cement concrete, but in proportions of 1 to 2 to 5. The concrete for the arch was drier than that used elsewhere in the work, and the inner and outer surfaces of the arch, and of all exposed work, were finished with a mortar facing. The arch-work proper (above the haunches) was built in eight or nine sections (lengthwise with the track), each section being built in a longitudinal form or mold supported on the lagging of the arch centering. Each section was built in one continuous operation, the concrete being tamped to straight edges defining the outside surface. The end sections included the parapet walls, which were carried up to a height of a few feet. The wing walls were built up continuously, and at first finished off in steps. A mold or form was then built on these steps and a smooth flat slope of concrete filled in, the slope conforming to that of the bank, and being finished off like a cement sidewalk. Other forms were also built for the parapets, which were then finished off to the final shape as a separate part of the work. The first and second parts of the parapet wall show very clearly in Fig. 4. Beyond the arch is seen the concrete-mixing machine.

Another large bridge over Brushy Creek, near Mattoon, Ill., is shown in Fig. 5. It has a 36-ft. arch for a waterway, and a 10-ft. arch for a roadway, with a 5-ft. pier between the two. The headway of the 10-ft. arch is 12 ft. at the center. The faces of the arch and parapet are plumb; the wings have a batter of ½-in. per ft. on the face, and 2½ ins. on the back, while the back of the parapet has a batter of 4 ins. per ft. The character of the concrete and the methods of construction are as already described for the 40-ft. arch. This structure, with approach embankments, takes the place of a span 80 ft. long. Mr. D. Sinclair, of Kankakee, Ill., was the contractor for this bridge and for some of the other structures here described.

A large number of concrete arches are being built for culverts, cattle-passes, private roads, drainage ditches, etc., ranging from 10 to 15 ft. span. The arches are as a rule quite flat. The 12-ft. arch has a radius of 16 ft. for a chord of 12 ft., and corner curves of 2 ft. radius to the face of the abutment, which has a batter of 1 in 24. For single track, the length of the culvert is 19 ft., or 20 ft. 6 ins. over the parapet walls. The thickness of concrete at the crown of the arch is 18 to 23 ins., and five lines of 10 to 12-in. I-beams, 16 ft. long, 2 ft. apart, are placed under each track, embedded in the arch work, with about 3 ins. of concrete below and 8 ins. above at the crown. The upper surface of the arch forms, with the parpets, a basin or trough in which the ordinary stone ballast is laid, so that the roadbed can be continued unbroken over the structure. The wing walls may be straight or flaring, and are finished off in steps or with a sloped coping, as desired. The invert has a radius of 26 ft. The amount of concrete in such a 12-ft. culvert is about 200 cu. yds. In concrete culverts with a steep fall, scouring under the 8-in. invert is prevented by apron walls at the ends, and occasionally at intermediate points. These walls are 18 ins. thick and 2 to 3 ft. deep below the bottom of the culvert. Small concrete culverts are also made, having openings 3 × 5½ ft., or 3 ft. diameter.

The culvert shown in Figs. 6 and 7 is typical of a great number of the smaller structures, some of which, however, are without the invert shown in Fig. 6. This is a 10-ft. culvert, with side walls 3 ft. 6 ins. thick at the springing line. Under each track are five 10-in. I-beams, 14 ft. long, spaced 2 ft. apart. The invert is 8 ins. thick, with an 18-in. apron wall 3 ft. deep at each end. This culvert contains about 190 cu. yds. of concrete. A somewhat similar class of structure, but having greater height, and used in replacing short trestles, is shown in Fig. 8. This has two 12-ft. arches, and 12-in. I-beams, spaced as before.

A method of repairing old culverts of stone masonry by concrete lining is shown in Fig. 9, but in other cases the arch is also lined. The culvert shown has new side walls and invert, but the arch is left unlined. In a 16-ft. arched culvert, the arch was lined with 8 ins. of concrete, and the portals and wing walls were also encased in 8 ins. of concrete to protect the stone from disintegration under atmospheric influences.

A style of structure which is being used in many cases to replace trestles, consists of plate girder deck spans of 60 to 80 ft. on masonry piers and abutments. Where the length of the structure was too great for a single span, steel trestle bents are erected on concrete piers. These carry the main girders, and also smaller girders, which extend back to the abutments. A structure of this kind is shown in Fig. 10, being the bridge on the east fork of the Galena River, near Council Hill, Ill. The steel bents are 60 ft. 8 ins. apart, c. to c., supported on concrete piers 16 ft. 6 ins. × 4 ft. under the coping. The upstream corners being faced with 10-in. I-beams 8 ft. long, as a protection against floating ice and drift. The abutments are of concrete, reinforced by transverse 10-in. I-beams, riveted to the flanges of inverted rails. The top of the abutment forms a beam to receive the ballast, which is retained by an end wall, which arrangement enables the standard track construction to be continued right up to the bridge floor. As this bridge is on a curve, the elevation is given in the cross-section of the abutments, as shown.

A long trestle over Coon River has been replaced by three 60-ft. plate girder spans with two steel bents on concrete piers and two hollow concrete tee-abutments. This structure contains about 450 cu. yds. of masonry.

In rebuilding its structure, the Illinois Central R. R. has for some time been using a novel form of T-shaped abutment, which was designed by Mr. H. W. Parkhurst, the Engineer of Construction. One of the special features is that it supersedes trestle approaches, as it fills in the space from the top of the bank slope to the end of the bridge proper, thus shortening the bridge floor very materially, and enabling the standard track construction (with ordinary ties and ballast) to be continued right up to the span. This construction is shown in Fig. 11, which represents a bridge over Lewis Creek, near Murphysboro, Ill. The main span is a deck plate girder structure of 56 ft., on masonry piers, which have been enclosed in concrete. The T-abutments take the place of short trestle approaches. Where there is prospect of double tracking, the width of the abutment is such that by adding another of the same size provision would be made for two tracks, 14 ft. c. to c.

As will be noted, the T-walls are comparatively short and extend but a little distance into the bank; and both abutments and "Ts" are nearly buried in the natural earth. They are built of concrete, with granitoid caps and bridge seats. To economize in material the "T" of the abutment is built in two separate walls, and to prevent these walls from spreading, bent rails are inserted as ties, whenever the height is sufficient to demand this precaution. The ends of the rails are bent at right angles so as to form anchors in the walls. At the top these two walls are connected by 10-in. I-beams, 10 ft. long, riveted to old rails embedded longitudinally in the top of each wall. These I-beams are spaced 20 ins. apart, c. to c., and upon them is built a trough-like concrete floor which carries the ordinary stone ballast.

The piers are similar concrete structures with granitoid capping; but in the upstream angles 10-in. I-beams are embedded diagonally in each corner, so as to protect these corners against damage from ice or floating debris.

SPECIFICATIONS FOR CONCRETE WORK; ILLINOIS CENTRAL R. R.

Following the descriptions of these concrete structures, we print nearly in full the railway company's specifications relating to this class of work:

CONCRETE MATERIALS.

CRUSHED LIMESTONE.—This shall be made by crushing tough, hard, clean limestone and screening same through 2-in. meshes or holes. The engineer or inspector in charge shall reject crushed limestone which may have any of the following defects: A. Containing more than 1% of the earthy or clayey matter; B, More than 20% of fine stone or stone dust, less than ½-in. in size; C. More than 5% of soft or rotten limestone which can be crushed or powdered up in the fingers; D. More than 10% of flat stone larger than 2 ins. in greatest dimensions; E. More than 15% of crushed stone larger than specified (passing through a 2-in. mesh), unless there be an equal amount of fine material less than ½-in. size; F. If any of the above classes of defective stone above named can be made good by mixture with additional material or by breaking the stone by hand, its use may be permitted under the direction of the engineer or inspector in charge: G. The use of clean gravel in place of not more than half of the specified amount of crushed limestone may be permitted at the option of the chief engineer, or his authorized representative; but the work shall be done under such special instructions as shall be given in each individual case, depending on the quality of the gravel used and other existing conditions.

CRUSHED GRANITE.—This shall generally be used of two sizes; a fine crushed granite, to be used as a substitute for sand, and a coarser size, particles of which are not larger than ¾-in. in greatest dimensions, and to be used as a substitute for crushed limestone in making bridge seats, pedestal stones, etc. All crushed granite shall be clean, entirely free from dust and earthy or clayey matter, and each grade shall be of practically uniform size. This material shall always be handled on platforms or plank, or in some way kept entirely free from admixture of earth, sand, etc.

SAND.—This shall consist of clean, sharp sand ("pit" or "bank" sand being preferred), and sand shall not be rejected if containing occasionally pieces of small gravel. A sand is preferred which will not pass through a sieve having 30 meshes to the inch. Sand shall be free from earth or alluvial matter; and, when tested by stirring with water or by rubbing in the hands, shall not show the existence of more than 0.5% of loam, clay or earth. No sand shall be used for the outside finish of any concrete which contains small particles of coal or of lignite, although sand of this character may be accepted for foundation concrete, or for the interior portion of any heavy piece of concrete work.

CEMENT.—This shall in all cases be approved by the engineer of bridges, and the inspector in charge of the work shall receive a written approval before permitting concrete to be made from any cement delivered. Where possible, cement shall be delivered in time to have samples properly taken and sent to the office of the engineer of bridges, for making the usual one-day and seven-day tests of neat cement. Contractors shall provide storehouses at the site of the several pieces of work in which to unload and store cement. Cement which is delivered on board cars must be unloaded promptly and stored in such warehouses, and the cars returned to the company's service. In no case will it be permitted to retain box cars on the work for the storage of cement. Cars which may be so held shall be charged to the contractors at the rate of one dollar ($1.00) per day for each day after the second day so held unloaded. Contractors shall be responsible for the proper care of this cement after it has been received and stored, and any cement injured through carelessness or neglect shall be rejected promptly by the inspector in charge. No brand of cement shall be used in any concrete work which has not been accepted in writing by the engineer of bridges, such acceptance to be based upon regular tests, where possible. The inspector shall, from time to time, make small pats of pure cement, and of cement mixed with sand, to satisfy himself that the cement actually used is of uniform character, and has not been injured by exposure to weather or in any other way, and may reject any cement which is wet or lumpy, or which fails to set properly in sample pats, and the contractor shall remove the same promptly from the work.

NATURAL CEMENT CONCRETE.—This may be used where foundations are entirely submerged below low-water mark or where there is no risk of the same being exposed to the action of the weather by cutting away the surrounding earth. It, however, shall be used only where a firm and uniform foundation is found to exist after excavations are completed. In all cases where foundations are liable to be exposed to the action of the water, or where the material in the bottom of excavations is soft or of unequal firmness, Portland cement concrete must be employed for foundation work.

The natural cement concrete shall usually be made in the proportions (by measure) of 1 part of approved cement to 2 parts of sand and 5 parts of crushed stone, all of character as above specified. For Portland cement concrete foundations, 1 part of approved cement, 3 parts of sand and 6 parts of crushed stone may be used. Wherever in the judgment of the engineer or inspector in charge of the work, a stronger concrete is required than is above specified, the proportions of sand and crushed stone employed may be reduced, a natural cement concrete of 1, 2 and 4, and a Portland cement concrete of 1, 2 and 5 being substituted for those above specified.

PORTLAND CEMENT CONCRETE.—Concrete for the bodies of piers and abutments, for all wing-walls for same, and for the bench walls of arch culverts shall generally be made in the proportions (by measure) of 1 part of cement, 2½ parts of sand and 6 parts of crushed stone. Where special strength may be required for any of this work, concrete in the proportions of 1, 2 and 5 may be used; but all such cases shall be submitted to the judgment of the engineer of bridges, before any change from the usual specification is to be allowed.

sary, ½ in. on the finished face of the work, it being the intention that any contraction shall open or that settlement shall effect a sliding action at such vertical joints, rather than to break up the concrete in the separate sections.

POINTING.

After the molds are removed, if there should be found any small pits or openings on the exposed faces of the concrete (or if bolts are used for securing the molds the ends of which are removed, leaving small holes), all such holes, pits or porous places shall be neatly stopped with pointing mortar, made of equal parts of cement and sand and mixed in small quantities to be used before the same shall set. Although it has not been specified to use a facing of mortar for such masonry as is to be permanently buried or covered by earthwork, such masonry shall not be constructed and left with pores and honey-combed surfaces. All such pores and openings shall be stopped with a pointing mortar, composed of 1 part of cement and 2 parts of sand, the same to be neatly filled into all openings and smoothly finished, in advance of any filling against such work.

NAME PLATE AND DATE.

A name plate and date shall be furnished by the contractor and put upon one piece of masonry at each bridge or job constructed by him, such plate to be of brass or copper or other durable metal, furnished with bolts or projections on the back to be buried in the concrete and to secure it firmly to the same, and having on it the contractor's name and the date of the year in which the concrete work is constructed. These plates should be placed upon the parapet walls of abutments, concrete arches and pipe culverts, and upon the ends of the bridge seats of piers, where they can be plainly seen and easily read. These should be set as the concrete work is finished and should be level with the surface of the same.

EXTRA WORK.

It is the intention of the foregoing specifications that work of all kinds shall be done by unit prices. It shall be paid for at rates per unit of measure of the several kinds of work required. Wherever, in the judgment of the engineer in charge, such prices are unfair to the contractor, the conditions shall be fully explained to the engineer of bridges, whose permission shall be obtained in writing for all extra work to be done. Generally such work shall be done at the actual cost, and the contractor shall be allowed 10% in addition, to cover superintendence, the use of tools, etc. No other rate will be allowed, unless specially provided when the work is ordered.

A daily report of forces employed and material used in all extra work shall be made by the foreman on the work to the assistant engineer or inspector in charge of the work, who shall check the same from day to day and settle all disputed questions as to labor and material used. A return of all such extra work shall be made by the contractor (or by his foreman) at the end of each month, which shall be given to the engineer or inspector on the work for certification, and shall be sent to the engineer of bridges, with the estimate of work done at contract prices, so that the monthly estimate may cover all work done during the month. In general, all bills for extra work claimed to have been done by the contractors shall be rendered monthly and shall be certified to by the engineer or inspector in charge of the work.

INCREASING THE REVENUE TRAIN-LOAD BY LARGE CAPACITY CARS AND IMPROVEMENTS IN CAR DETAILS.*

By F. F. Gaines.†

Recent improvements in rolling stock have resulted in the attainment of such a position that any future improvements for the increasing of revenue load are to be sought for in close attention to details, rather than radical changes in designs.

One of the greatest of the economies that have been recently introduced is the concentration of train-load on a short total wheel base by the use of large capacity cars. While this is generally known and understood, it is not so universal that an analysis of the causes, and results attained will not be of interest. A train of cars being hauled through a curve is somewhat analogous to checking the pull on a rope by taking a turn around a post and pulling on the free end. The resistance necessary to be overcome in hauling the rear of the train is similar to the pull on the free end of the rope, the curve (together with this pull) furnishes the restraining force in the form of flange friction. It is also probable that the rolling friction between rail and wheel is not altogether in proportion to the weight on the wheel, so that for two trains of equal weight on a straight and level track that which has the fewer number of wheels will offer the less resistance. From data secured in various tests on a number of roads I find that a train of average empty cars (each car averaging about 15 tons light weight) requires 30% more power for the same tonnage, or the same engine can only handle 70% of the weight of an average loaded train composed of

*From a paper read at the May meeting of the New York Railroad Club.

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TABLE I.—Results of Tests of Freight Trains Made up with Cars of Various Capacities.

Test train number.....	1.	2.	3.	4.	5.
No. loaded cars in train.	36	37	47	55	66
Nominal capacity, tons..	50	40	30	25	20
Weight:					
Car and contents, tons.*	70.0	60.0	42.5	36.4	30.5
Total, cars & contents†	2,500	2,207	2,000	2,003	2,012
Light; all cars (tare wt)	676	680	636	649	676
Revenue load, tons.....	1,824	1,527	1,364	1,354	1,336
Coal burned on trip, lbs..	18,264	18,457	18,242	19,511	19,659
Per trip in per cent...	100.0	100.0	100.0	106.5	107.3
Total train length, ft.‡..	1,209	1,249	1,540	1,632	1,958
Weight: Gross, per cent.§	125	110.35	100	100.15	100.6
Revenue, per cent‡.....	133.70	111.95	100.00	99.27	97.95

*Average. †Gross weight in tons. ‡This excludes engine and caboose. §Gross weight of train 3 = 100. ‡Revenue weight of train 3 = 100.

60,000-lb. capacity cars. This would probably hold true on account of the foregoing reasons if a train were composed of loaded cars weighing (with contents) about 15 tons, it being a question of length of total wheelbase of train, independent of the ratio of lading to total weight, but directly proportional to the gross weight of cars.

The accompanying tables show results of tests of trains made up of cars of various capacities.

All the trains were hauled by the same engine and over the same divisions. From the actual test data (Table I.) you will note that trains Nos. 1, 2 and 3 used about the same amount of coal per trip, while trains Nos. 4 and 5 varied somewhat. If we call the coal per trip used with trains Nos. 1, 2 and 3, 100%, and deduct from trains 4 and 5 the percentage of train weight indicated by extra coal consupmtion, all trains may then be considered as having the same resistance, and the total weights and revenue loads are then comparable; the revised figures are shown in Table II.

Considering the revenue load in the normal train of 60,000-lb. cars as 100%, that in the train of 40,000-lb. cars is 90.76%; in the train of 50,000 lbs. capacity cars is 92.82%; that in the train of 80,000 lbs. capacity cars is 111.95%; and that in the train of 100,000 lbs. capacity cars is 133.7%. Is not the gain of revenue load from this source sufficient to warrant the retirement of light capacity cars, say 20 tons and under?

The tests and chart only apply to cars for handling heavy raw material in bulk, such as ore, coal and pig iron, and modifications due to heavy grades have been neglected. When we come to the box car where the lading may be anything from straw hats to pig lead, the proper size and capacity of car is still an unsettled question. Except in isolated cases where there is a special line of business, which affords a normal full load and where circumstances permit of keeping heavy capacity cars for this trade in their home territory, can the revenue load be increased by exceeding a box car of 80,000 lbs., or even 60,000 lbs. capacity for general use?

Before leaving this part of the subject it is to be noted that there is an additional economy in the use of large capacity cars normally loaded, due to minimum track room occupied in sidings and yards, and the smaller number of units to be handled in making up and dispersing trains.

Taking up some of the lesser items that have an influence on attaining the desired result, truck design is undoubtedly an important factor. The old archbar truck had much the same bringing up as "Topsy"—just grew. With flexible members, that were rarely if ever strong enough and roughly put together, it was more accident than good design if the axles were parallel. When they were out of line we had as a result increase of wheel and journal friction and decrease of revenue load. The pressed or structural steel truck, with solid side frame, absolutely rigid as regards the parallelism of the axles and squareness of frame, was a decided step in advance. Contemporaneous with the growing use of the solid side truck, rational methods of design were applied to the archbar truck, and the members made strong and rigid enough to prevent distortion; the members themselves in some designs, were changed from merchant bars to structural and pressed steel sections. As a result we now have trucks of the archbar type strong enough to always retain the parallelism of axles and yet flexible enough to readily accommodate themselves to varying conditions of track. Is it not possible to have too much rigidity, and is not the well designed modern archbar truck at least as desirable as the more rigid solid side type?

Whether it is advisable to use truck and body bolsters strong enough to carry the load and be center bearing, or to depend on some form of frictionless side bearing, if there be such a thing, is an open question. That there is warrant for one device or the other needs no proof. I have seen cars with weak bolsters and the average side bearing which, when run through a lead on a siding, would refuse to run on a fair grade with a good start. I have the data of two tests made on different roads to determine the amount of resistance due to this factor, in trial trains over a division. In one test it required 8.5% more power and the engine consumed 2½ tons more coal in hauling the non-center bearing train of equal weight. In the other test, the same engine being used for both trains, the coal consumption was 22.5% less for the center bearing train. As both trains were handled by the same

TABLE II.—Virtual Results, on Basis of Equal Coal Consumption.

Test train number.....	1.	2.	3.	4.	5.
No. loaded cars in train.	36	37	47	52	61
Nominal capacity, tons..	50	40	30	25	20
Weight:					
Car and contents, tons.*	70.0	60.0	42.5	36.4	30.5
Total, cars & contents†	2,500	2,207	2,000	1,873	1,865
Light; all cars (tare wt)	676	680	636	607	627
Revenue load, tons.....	1,824	1,527	1,364	1,266	1,238
Coal burned on trip, lbs..	18,264	18,457	18,242	18,321	18,321
Per trip in per cent...	100.0	100.0	100.0	100.0	100.0
Total train length, ft.‡..	1,209	1,249	1,540	1,543	1,810
Weight: Gross, per cent.§	125	110.35	100	93.65	93.25
Revenue, per cent‡.....	133.70	111.95	100.00	92.82	90.76

*Average. †Gross weight in tons. ‡This excludes engine and caboose. §Gross weight of train 3 = 100. ‡Revenue weight of train 3 = 100.

engine and crew, the total weight of train being the same, it requires 22.5% more power to handle the non-center bearing train. For the same amount of power the engine could have hauled 22.5% greater tonnage if the cars had been center bearing, and, as the proportion of net weight was 68.2% of the gross weight, the revenue load would have been increased by 15.4%. Frictionless side bearings may accomplish the same results, but that proposition is yet to be demonstrated. While the stiffer bolsters required for center bearing cars may be more expensive on account of first cost, would not this be more than offset by the necessary attention and care to properly maintain any form of frictionless side bearing? Is the increased load due to the use of free swiveling trucks sufficiently large to pay for putting in new body and truck bolsters or frictionless side bearings on cars that are not so equipped?

Another item which, while small, is not insignificant, is the center plate friction. Our car capacities have increased from 40,000 to 100,000 lbs.; has the bearing area been increased in proportion? The value of systematic lubrication of center plates is beginning to receive attention. Experiment shows that it is warranted. The form of the center plate itself is an important factor in the maintenance of lubrication. If the bearing surface is on a level with the king-pin hole, with no provision for the retention of the lubricant, only a heavy grease that will not run is of any value; while a form that allows of the bearing surface being lower than the pin opening will form a reservoir for the oil and only requires an additional supply at long intervals. It would also seem reasonable that there is a choice of the material to be used. Is malleable iron, cast iron or pressed steel the best adapted for good contact and reduction of friction? And, in view of the fact that the unlubricated center plate causes considerable rail friction, is the cost of providing permanent lubrication justifiable?

The proper adjustment of brake beams frequently receives less attention than it deserves. The scrap heap will reveal the fact that a great many shoes are removed on account of one end being worn down completely, with little or no wear on the other end. This can be almost wholly attributed to the manner in which the brake beams are hung—allowing one end of the shoe to drag on the wheel. Stand by the track as a train passes and you will hear the shoes rubbing on the wheels with surprising frequency—especially if the cars in the train are someone else's cars and not our own. Considering the small cost necessary to eliminate this source of friction, is it not worth more attention?

In conclusion, is it not safe to say "that by taking heed to ourselves" we can increase our revenue train-load in several ways? And how far is the first cost of refinements that contribute to this end justifiable?

DISCUSSION.

Mr. F. M. Whyte.—We are probably making a mistake in not increasing the diameter of wheels in proportion to the increase in diameter of axle journal under large capacity cars, and I am informed that some observations made recently indicate that the increase in resistance due to increasing the diameter of journals without increasing correspondingly the diameter of wheels has seriously reduced, if indeed it has not entirely offset, the advantage of the decrease in tare weight and flange resistance of the heavy capacity cars. With the larger axles now in use under cars we should be using 36 and 38-in. wheels to maintain about the relations of the 4¼-in. journal and 33-in. wheels.

In regard to oiling the center plates, we might gain much by turning the center plates bottom-side up. As they are placed now, they are just right to catch and to hold between the wearing surfaces the dirt, rust and coal dust, but if the plates are turned bottom-side up, the rust and dust would fall from between the center plates and lubrication would not be so much needed.

It is not always true that a certain tonnage in a short train can be hauled over a division easier than can the same tonnage be hauled in a longer train; there are roads on which the longer trains can be hauled easiest. For instance, trains in length between 3,000 and 4,000 ft., not unknown by any means, might be longer than the longest curves; there the curve resistance of the entire train would not be experienced at any one time; also the grades might be of such length that grade resistance of the entire train, if effective at one time, might be of

These fillets may be made in short pieces and fastened neatly into the mold as the layers of concrete are carried up. Such I-beams will generally be furnished of sufficient length to extend at least 6 ins. above the top of the battered masonry into the concrete coping, and special pains shall be taken to tamp the concrete thoroughly around the I-beams, and to finish the coping above and around the ends of the same, so as to make a compact and solid bearing against the iron work.

Where anchor bolts for bridge-seat castings are required, they shall be set in place and held firmly as to position and elevation, by templets, securely fastened to the mold and framing. Such I-beams and anchor bolts shall be embedded in the concrete work without additional expense beyond the price to be paid per yard for the several classes of concrete in which such iron is placed, the volume of iron being estimated as concrete.

After the work is finished and thoroughly set, all molds shall be removed by the contractor. They shall generally be allowed to stand not less than 48 hours after the last concrete work shall have been done. In cold weather, molds shall be allowed to stand a longer period before being removed, depending upon the degree of cold. No molds shall be removed in freezing weather, nor until after the concrete shall have had at least 48 hours, with the thermometer at or above 40° F., in which to set.

PLACING CONCRETE.

Concrete shall generally be placed in the work in layers not exceeding 6 ins. in thickness, and, in general, one layer shall be entirely completed before another one is commenced. If delivered by wheelbarrows it shall be dumped as closely as possible where required, so as to avoid as much as possible the handling or turning over the same by means of shovels within the excavation or mold. Where it is not practicable entirely to complete one layer before commencing a second one, a plank 6 ins. wide or more, shall be securely fastened into the excavation or mold, against which the end of the layer of concrete shall be rammed, thus providing for a vertical joint in this layer of concrete, and if a second layer has to be stopped short of the full length of the work, a second cross plank, placed at least 1 ft. back from the end of the first layer, shall be secured to the excavation or to the mold, against which to ram the second layer of concrete. Layers of concrete masonry must not be tapered off in wedge-shaped slopes, but must be built with square ends in the method above described, and the surface of each projection shall be finished hard and smooth, and flushed full of mortar, no porosities or loose stone being left thereon. Layers must not be made of greater thickness than 6 ins., unless specially permitted, and each layer must be thoroughly rammed, and the concrete must be of such consistency that heavy ramming will produce a slight quaking action. In other words, the concrete must be so thoroughly compacted that there will be no pores or open spaces between the stone of which it consists, which are not thoroughly filled with mortar.

The inspector shall insist upon the thorough compacting and ramming of all concrete, and shall see that a sufficient number of men, furnished with suitable rammers, are assigned to this work. Enough men shall be employed ramming, so that each batch may be spread and rammed before another batch is dumped within the mold. The ramming must be completed as the work progresses.

Foundation concrete, if put into excavations which are not protected by molds, need not have any special attention given to the finish of the concrete against the earth around it. Where it is necessary to use molds in the construction of foundation work, the finer material of the concrete shall be worked to the outer portion of the mass against the molds, so as to insure the filling with mortar of all pores or open spaces between the concrete stone. As before described, the top surface of all foundation concrete shall be finished, so that no loose stone or open and porous places are left upon the same, especially in the portions of the foundation which project outside the upper portion of the work. If necessary, the inspector shall have the contractor make batches of mortar, consisting of 1 part of cement to 3 parts of sand, the same being thoroughly mixed, and shall cover the whole surface of the foundation concrete with enough of this mortar to flush full all such open, porous places.

A facing of mortar, consisting of 1 part of cement (by measure) to 2 parts of sand, shall be put in next to the molds, for all Portland cement concrete work for piers, abutments, arches, wing walls, parapet walls, and any other places where directed by the engineer in charge, to form a finish for all such parts of the above classes of work as are to be exposed to the weather, or which are liable to become so exposed. A similar facing shall be used for the top surface of all concrete masonry not finished with granitoid work, and such surfaces shall be finished in the style of sidewalk work.

It is not intended to use such a facing on the backs of abutments or wing walls, against which earth filling is to be placed, and where the same must necessarily be maintained, but the same shall be used for the faces and for the upper 12 ins. on the backs of all wing walls, for the backs of parapet walls, for the intrados of all arch work, and as a plastering on the outside of the same, and in all such places where the washing away of earth may expose concrete work to the action of the weather. It is not intended to use such facing for any copings, bridge-seats, parapets, etc., which are to be of granitoid construction. The exact thickness of 1½ ins. for this facing shall be secured in the following manner: A piece of sheet iron 6 ins. in width (the height of one course of concrete), and of any convenient length, say from 6 ft. upwards, having small angle irons, the projecting leg of which shall be 1½ ins. in width riveted to its face, at intervals of about 2 ft., and provided with handles standing above the upper edge at or near each end, shall be furnished by the contractor for use at each piece of work where necessary. This piece of iron plate, if placed with the projecting angles against the face of the mold, will leave a space of 1½ ins. between it and the mold. This space shall be filled with the mortar required for the facing, which mortar shall be mixed in small batches from time to time as needed for the work. When the space between the iron plate and the mold is filled and tamped with a shovel or other tool to insure complete filling of the whole space between the iron plate and the face of the mold, and when the layer of ordinary concrete is backed up against this iron plate, it is to be withdrawn by means of the handles and the whole mass of concrete rammed in one uniform layer. The inspector shall see that the space of 1½ ins. is entirely filled with the mortar, which should be of such consistency that it will flow somewhat freely. At the same time this mortar must not be made so thin that the crushed stone may be formed through it in the process of ramming. By using the mold in the manner above described, the face of each layer may be made of exactly the right amount of mortar, and the proper thickness of the layer may be accurately determined. The intention is that the facing and the backing shall be rammed and set together. In no case is one to be put in in advance of the other, or so that either may set before the other. In no case shall the inspector or engineer in charge permit any work to be finished by plastering mortar on concrete which has set, but should it become necessary at any time to refinish a surface which has set, it shall be picked off so that at least 3 ins. of mortar can be added, and the surface of the old concrete shall be roughened and thoroughly wet before new material is added, such new material being mortar as specified for facing.

Layers of concrete shall be kept truly horizontal, and if, for any reason, it is necessary to stop work for an indefinite period, it shall be the duty of the inspector and of the contractor to see that the top surface of the concrete is properly finished, so that nothing but a horizontal line shall show on the face of the concrete. The joint between portions of the work constructed before and after such period of delay. If, for any reason, it is impossible to complete an entire layer, the end of the work shall be made square and true by the use of a temporary plank partition. No irregular, wavy or sloping lines shall be permitted to show on the face of the concrete work as the result of constructing different portions of the work at different periods, and none but horizontal or vertical lines shall be permitted in such cases.

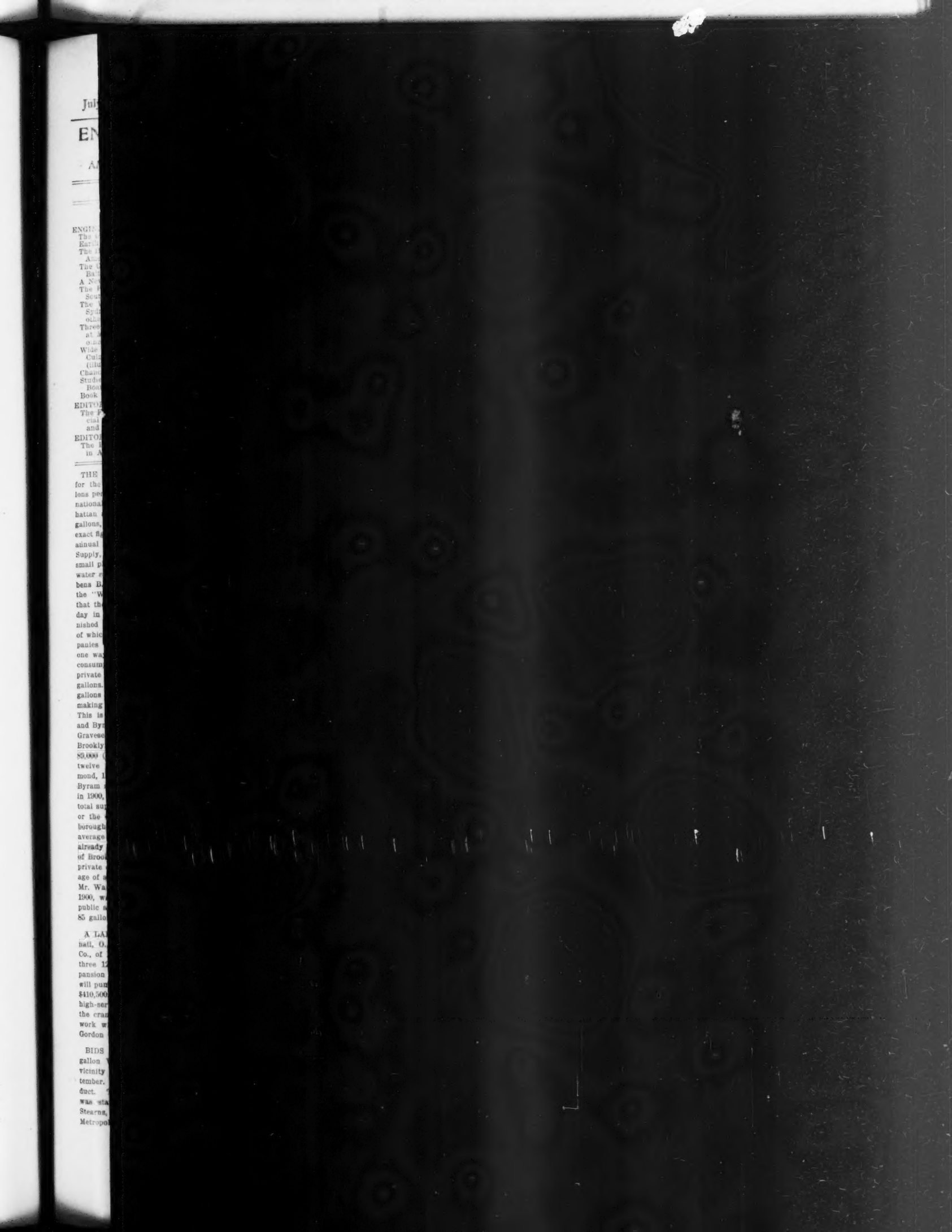
Where concrete is to be put into a foundation below water level, all water shall as far as possible, be removed from the excavation. If it is impossible by means of the ordinary pumping facilities to control the flow of water, the excavation may be taken out in sections and the concrete may be placed in the foundation, section by section. Special care should be taken to ram thoroughly the bottom layer of concrete, and to remove all mud and clay from the vertical face of each section of concrete as additional sections are excavated and prepared for addition of concrete work. Where the foundation is soft, as, for example, where piles are used, either fine or coarse broken stone may be spread over the bottom of the excavation and thoroughly rammed into the earth before putting in any concrete. In no case shall a dry mixture of sand, cement and crushed stone be put into a foundation. The concrete may be mixed with a less proportion of water, but should not be placed in the foundation without thorough mixing. Where strata of gravel and sand permit the entrance of water into the foundation with such freedom that small sections of the same cannot be excavated and pumped out for concreting, a grout of pure cement or of a mixture of cement and 1 or 2 parts of sand may be injected through a pipe into the loose gravel and sand in the bottom of the foundation; this work being done while the excavation is filled with water. The pipe through which this grout is passed should be pushed a few inches below the surface of the gravel, and a bucketful or more of grout should be poured down through the pipe, the pipe being then moved 1 or 2 ft., and the operation repeated, distributing the grout over the whole area of the bottom to be thus cemented, and the work then should be allowed to stand for 24 to 36 hours. It will generally be found that the sand and gravel will be converted into a water-tight concrete, permitting the pumping out of the excavation.

Where it is impossible to complete parapet walls, copings, etc., on account of stringers or other wood or iron work necessary to maintain structures over which tracks are in use, all work shall be finished to horizontal and vertical lines, and with surfaces filled with mortar, so that when possible to complete the concrete work, the joint between the new and the old work shall show nothing but straight, level and vertical lines.

EXPANSION JOINTS.—Where masonry structures are more than 100 ft. in length, such provision for expansion joints shall be made as may be specified by the engineer of bridges or his assistants. Generally in the construction of large arches, or of smaller, long concrete arches, the work shall be subdivided into sections of approximately 25 ft. in length, each section being separated from the adjacent one by a vertical joint extending entirely through the bench walls, arch rings, etc.; bu the foundation work shall be stepped as previously explained, and made in one continuous monolithic mass. Temporary vertical partitions shall be put into the molds, against which the concrete shall be thoroughly rammed, where arch culverts are subdivided into short lengths as above specified, these partitions being removed as each sections is completed and the next adjacent section being rammed against the concrete already constructed and set. The joints thus made shall not be flushed with mortar, nor shall any attempt be made to make the fresh concrete adhere to the older work, but a small beveled strip of wood shall be set in the angle next to the temporary partition so as to make a "V" groove, defining the joint and leaving a depth of

FIG. 5. CONCRETE BRIDGE OVER BRUSHY CREEK; ILLINOIS CENTRAL R. R.

FIG. 7. VIEW OF STEEL CONCRETE CULVERT; ILLINOIS CENTRAL R. R.



such short duration that the possible momentum would supply the deficiency of the locomotive; also at certain stopping points at or near the foot of an opposing grade, the long train may extend back on an assisting grade. Such conditions accumulated might make it more desirable to operate long trains rather than short ones and I have in mind divisions of road where it is believed that the longer trains are more easily operated than short ones.

A number of investigators say that a certain tonnage of empty cars has from 30 to 33% greater resistance than the same tonnage of the same kind of cars loaded to their capacity; this may be a fact, but, personally, I am not yet prepared to accept it as such. Some additional data on the subject may be available later. My remarks are not to be understood as opposed to larger capacity cars; there are too many conditions strongly in their favor to make it necessary to imagine others.

Our efforts in car design tend to decrease the length of trains, our efforts in locomotive design tend to increase the length of trains; it is probable that the net result is a gradual increase in train length and this brings before us the necessity of devising some means other than the present visual method of signaling from the train to the locomotive; I believe that this question of signaling requires quite as serious consideration as any question now before us for the handling of freight trains with dispatch.

Mr. Gaines.—We have some dynamometer records on the drawbar pulls of different kinds of cars, and there is no question that a train composed of 100,000-lb. capacity cars not only pulls easier than that same tonnage in a train of say 60,000-lb. capacity cars, but it pulls 25% easier.

In this case the trains compared were very similar in resistance and other respects, except the actual capacity of the cars. I feel perfectly safe in stating that the large capacity car, notwithstanding that theoretically an increased journal would give you greater friction on account of the speed, shows by the actual results that this is not realized at all.

Prof. E. B. Lovell.—Mr. President, it may add to the general understanding of the subject to call the attention of the club to the result of the experiments which were conducted to determine the coefficient of friction under varying loads. It has been found that the coefficient varies with the unit load; that is, the heavier the unit load on the journal, the less will be the coefficient of friction. Numerous experiments have shown this to be true. This will explain in part why the total journal resistance of a train composed of large capacity cars is less than the total journal resistance of a train of equal gross weight but composed of a greater number of cars of lighter load; this is undoubtedly true, notwithstanding the fact that the journal of the large capacity car has been increased, while the diameter of the car wheel has remained constant. The weight on the axle, multiplied by the coefficient of friction, gives the friction at the journal. This, multiplied by the ratio of the journal radius to the wheel radius, gives the journal resistance as measured at the drawbar. The product, although containing a ratio that amounts to a longer leverage, is less than the product of a greater friction at the journal by a less leverage.

There is another factor that exerts a great influence upon the total train resistance that has not been spoken of this evening. I refer to the wind resistance. This will vary with the speed, with the shape of the cars and their relation to each other in the train. The greater the exposed surface, the more openings between cars, the greater will be the resistance due to the wind. Here again the large capacity car has the advantage.

In the table presented by the author of the paper this evening, we find that the long trains composed of lightly loaded cars, show the greater coal consumption. This is due to the combined effect of many causes, but in part to the increased wind resistance of the longer trains.

Closely related to this subject is another point, brought up by the speaker this evening, that I wish to refer to. Mr. Graves compared the efficiency of the various trains directly upon the basis of total coal consumed. That is hardly a fair or correct method of calculating the efficiency. Coal consumption does not vary directly with the distance run, and if not with the distance run, then certainly not with the number of cars or the capacity of the cars making up the train. Wellington estimated that from 30 to 40% of the coal consumption is independent of the distance run. This covers the part that is consumed while standing still, at stations or in the roundhouse, or that is consumed while shifting cars or that escapes at the safety valve. It is necessary, therefore, to deduct from the total coal consumption of each trip the amount chargeable to the locomotive making the trip, and then make proper allowances for the difference in actual running time of the trains, as well as for the different methods of firing or of loading the locomotives, before an exact calculation of the efficiency of the different classes of cars can be made upon the basis of coal consumption.

Mr. Geo. L. Fowler.—A great deal of trouble is being experienced on several roads from the fact that the center plates are wearing and cutting very rapidly, letting the car down to such an extent that they are putting an excessive weight on the side bearings, with the resultant friction and the difficulty in rounding curves. I looked into the matter of the center plates a short time ago, and found to my surprise that the design of the center plate —well, there was not any design. I found on cars of 60,000 lbs. capacity that the weight on the center plates varied from about 300 to about 4,000 lbs. per sq. in. of bearing surface. I found that on one road 60,000-lb. capacity cars out of the same shop had two cast-iron center plates; one of them was carrying about 400 lbs. to the sq. in., and the other was carrying about 3,000 lbs. I don't know whether the same draftsman made the drawings of the center plates or not, but they came from the same road and out of the same shops.

Professor Lovell.—If the author's statement in his paper is correct, power is lost in consequence of the obliquity of traction, as distinguished from curve resistance, and this loss becomes more serious as the length of the train increases, giving advantage, therefore, to the train of large capacity cars.

Let us inquire now how the tractive power is transmitted through the several cars of the train. The tractive force passes from the rear drawbar of the advance car to the front drawbar of the car following, through the body of the car to the rear drawbar of the same car, where it is transmitted by a similar process through the next car, and finally to the rear end of the train. The change of direction in the line of tractive force is, therefore, at the drawbar. If there is a loss due to obliquity of traction it must occur at the coupling. There is absolutely no resisting force at this point to be overcome, except that due to the friction between the couplings, which is so small that it can be neglected in all practical considerations. The only effect, then, that the obliquity of traction can have is to reduce curve resistance. It is an active force, although of small value, which assists to overcome the resistance of lateral friction between wheel and rail. It is not sufficient to overcome that friction entirely; it does not result in drawing the car down on the inside of the curve; or in tumbling them over the inside rail. Such a condition would not result if the train were 300° long. Each truck of the train, if the axles are parallel and the wheels of equal diameter, tends to roll in a straight line, and each truck in the train tends to occupy identically the same position when passing any point as every other truck occupied when passing the same point. This must be the condition regardless of the number of cars in the train. We fail to establish, therefore, a condition in the train similar to the rope wrapped around the tree or snubbing post, to which the action of the train passing a curve has been likened this evening.

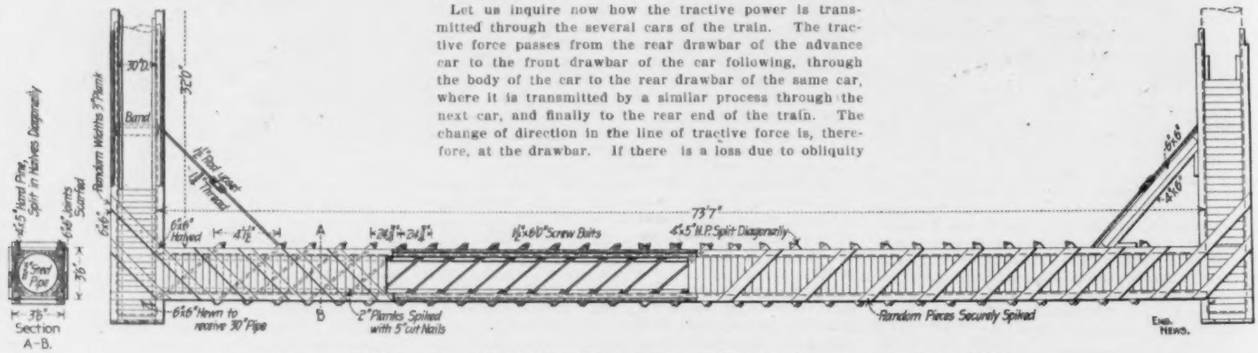


FIG. 1. SIPHON FOR MASSACHUSETTS PIPE LINE GAS CO., AT EVERETT, MASS.

SUBMERGED INVERTED SIPHON OF THE MASSACHUSETTS PIPE LINE GAS CO., AT EVERETT, MASS.

By W. W. Cummings.*

What is possibly a little out of the ordinary line of inverted siphons was placed across Island End River, in Everett, Mass., on May 21. The characteristics were its economy and rigidity for a rather unusual length.

The Harbor Commissioners required that a clear waterway 60 ft. wide and 18 ft. below mean low water should be preserved. The river bottom at this point is but 4 ft. below mean low water, the channel as yet not having been dredged.

As shown by the drawing, Fig. 1, and the view, Fig. 2, the siphon was made up of a 30-in. riveted steel pipe ⅜-in. thick, the legs being about 52 ft. long and the extension piece about 74 ft. long on centers. The pipe was enclosed in a box 36 ft. square, made up of 6 × 6-in. spruce corner posts, with 3 × 4-in. sticks spiked to them for the filling of the 2-in. cover planks.

It was designed to make the siphon as light as possible; therefore, the steel pipe was figured to be self-supporting when hung by the two legs and only sufficient concrete was added to sink the pipe and its enclosing box. The sides of this box formed two trusses calculated to support the box and the contained concrete when hung by the legs of the siphon, or to have sufficient excess of strength when submerged and supported at its center to make up the deficiency in the steel pipe when supported at that point. Particular care to secure an even bottom in the dredging was, therefore, unnecessary. The angles of the siphon were reinforced by 1½-in. tie-rods and two 6 × 8-in. struts bearing on pieces of angle iron.

The weight of the siphon complete was about 60 tons, or 900 lbs. per lin. ft., and nine tons, or 125 lbs. per lin. ft. when submerged.

The pipe and the extension piece of the box were constructed on shore. These were then placed on temporary piling in the channel by means of a lighter. Concrete composed of one part Star cement to one part unscreened fine gravel was added, after smearing the joints of the steel pipe with neat cement mortar. The legs of the box were then carried up, the concrete being added as the work progressed, and the whole allowed to set six days. Particular care was taken to make the concrete impervious to water. In placing the siphon three lighters were used, one large one on one leg and two smaller ones on the other. When lifted free from the blocking the deflection at the center was about 1½ ins. The lowering consumed about two hours. When in place the pipe was under a maximum head of 26 ft., and remained 24 hours without showing any leaks. It was then filled with water and allowed to settle to its bearing.

The whole siphon, with the exception of the 6 × 6-in. and 3 × 4-in. spruce timber, was made from the scrap pile at a cost of $593. The material new would have cost about $685, making a total new of about $9 per lin. ft. The dredging cost $1,800, and the placing about $600.

Without searching the records, it is believed that this is the longest and largest siphon in the vicinity, that of the Boston Water Department, at the Warren Bridge being 24 ins. in diameter and 55 ft. long, and that of the Metropolitan Water Board, at Saugus River, being 20 ins. diameter and 48⅔ ft. long. The latter cost $23 per lin. ft. It might be added that the siphon was subject to extremely rough usage while being lowered, but it was perfectly rigid, and the concrete showed no signs of cracking.

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